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PROCEEDINGS

TENTH

RICE TECHNICAL WORKING GROUP

Held June 17-19, 1964, at University of California
Davis, Calif.

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Experiment Stations and Agricultural Extension Services
of
ARKANSAS, CALIFORNIA, LOUISIANA, MISSISSIPPI, AND TEXAS

and the

Agricultural Research Service

Consumer and Marketing Service

Federal Extension Service

UNITED STATES DEPARTMENT OF AGRICULTURE

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PROCEEDINGS, TENTH RICE TECHNICAL WORKING GROUP

HELD JUNE 17-19, 1964, AT UNIVERSITY OF CALIFORNIA, DAVIS, CALIF.

RICE TECHNICAL WORKING GROUP

Organization and Purpose

The Rice Technical Working Group functions pursuant to an informal memorandum of understanding among the State Agricultural Experiment Stations and Agricultural Extension Services of Arkansas, California, Louisiana, Mississippi, and Texas, and the Agricultural Research Service, Consumer and Marketing Service, and Federal Extension Service of the United States Department of Agriculture. Its membership is composed of personnel in each of these agencies who are actively engaged in rice research and extension. Participants from the States are designated by the directors of the state experiment stations and extension services concerned. USDA representatives are designated by the service or branch concerned with rice research and extension. An administrative advisor is elected jointly by the experiment station and extension service directors.

Other officers of the group consist of a chairman and a secretary elected by the membership. Interim affairs are handled by an executive committee consisting of the elected officers, administrative advisor, executive secretary of the USDA Rice Research and Marketing Advisory Committee, and two elected members, one of whom is an active research worker on rice in a state agricultural experiment station and the other an active state agricultural extension worker on rice.

The Rice Technical Working Group meets at least biennially to provide for the continuing exchange of information, cooperative planning, and periodic review of all phases of rice research and extension being carried on by the States and the Federal Government. It develops proposals for future work which are suggested to the participating agencies for implementation.

This Working Group had its origin in a conference on drying and storage of rough rice held by State and Federal agencies at Beaumont, Tex., in 1949.

Date and Place of 1964 Meeting

The tenth meeting was held June 17, 18, and 19, 1964, at the University of California, Davis, Calif. Officers in charge at the meeting were: Francis J. Williams, chairman; Joseph T. Hogan, secretary; Milton D. Miller, State Extension Service representative; Nathan S. Evatt, State Experiment Station representative; and E. M. Cralley and W. C. Dachtler, administrative advisors.

Officers Elected

Officers elected to serve for the next 2 years are: Chairman, Joseph T. Hogan, Southern Utilization Research and Development Division, ARS, USDA, New Orleans, La.; secretary, D.S. Mikkelsen, Department of Agronomy, University of California, Davis, Calif.; State Experiment Station representative, C.C. Bowling, Texas Rice-Pasture Research and Extension Center, Beaumont, Tex.; State Extension Service representative, Ruel P. Nester, Arkansas Agricultural Extension Service, Little Rock, Ark. W.C. Dachtler and E.M. Cralley will serve as administrative advisors to the group.

Date and Place of 1966 Meeting

The next meeting (11th) of the Rice Technical Working Group will be held in Little Rock, Ark., during June 1966. The exact time and date will be determined by the executive committee.

Moderators for the next meeting of the Working Group named during the main business meeting were: Breeding, Genetics, and

Cytology, C.N. Bollich; Rice Diseases and Insects, H.A. Lamey; Drying and Storage, M.D. Faulkner; Cultural Practices, Soils, Fertilizers, and Weed Control, J. L. Sims; Economics and Marketing, M.E. Miller, Education and Extension, Don Adams; and Processing, Composition, and Nutrition, V. R. Williams.

RECOMMENDATIONS OF THE PANELS

RICE BREEDING AND GENETICS

C. R. Adair, Leader, C. N. Bollich, H. R. Caffey, N. E. Jodon, T. H. Johnston, Johan Mastenbroek, John Scott, James Stansel, and J. R. Thysell

The rice breeders and geneticists on this panel realize that the primary purpose in rice breeding is to develop varieties that will assure a maximum and stable production of the type of varieties required by producers and consumers. Basic research is necessary in order to relate the complex of morphological, physiological, and chemical differences among rice varieties to yield and the chemical and physical characteristics of the grain. This will require close cooperation with researchers in related disciplines. Specific problems to be solved and types of cooperative research to solve them are as follows:

Genetics and Cytogenetics

1. A study of the mode of inheritance of many characteristics, such as

   (a) reaction to diseases, insects, pesticides, temperature, and to levels of soil fertility and other soil and water characteristics such as alkalinity and concentration of salts;

   (b) resistance to lodging; and

   (c) properties associated with cooking and processing characteristics.

Genetic and cytogenetic research also should include the synthesis of strains with a normal complement of chromosomes that have marker genes for use in linkage studies. A search also should be made for the 12 trisomics in rice as these could be used in linkage studies.

Response to Temperature, Light, Photoperiod, Alkalinity, Salinity, and Emergence through Water

Varieties differ widely in their response to these environmental factors. Research is needed to elucidate the basic principles involved, to develop techniques for determining varietal reaction and to study the genetics of these characteristics. These studies will include such practical problems as reaction to low temperature of soil, water, and air; excessively cloudy weather; alkalinity and salinity; and the optimum seeding date for each variety. Consideration also should be given to the development of varieties with lower water requirements from the standpoint of maturity, plant type, and other characters.

Resistance to Diseases and Insects

Intensive studies in close cooperation with pathologists and entomologists are required to develop varieties that are resistant to the important diseases and insects.

Straw Strength, Fertilizer Response, and Yield Components

The factors contributing to straw strength, fertilizer response, and yield components are intimately associated in the total production and quality of the grain of a variety. These factors must be studied as a whole in order to fully understand all of the problems and their relationships. Straw strength may be determined by the histology, morphology and possibly by chemical constituents of the plant (culm). These factors are influenced by quantity, quality, and time of applying fertilizers. There, also, are varietal differences in culm length and diameter and thickness of culm wall; cell

structure, arrangement, and composition; and number of nodes and length of internodes. Root development also should be studied as this probably is a factor in lodging, especially when rice is sown in water. Time of application of fertilizer influences response both in vegetative organs and in seed production. This probably is related to stage of development and may differ among varieties. Yield components should be determined and studied with the objective of combining the optimum of tiller number, panicle size, and other components for each grain size and shape. The effect of time, rate, and composition of fertilizer as related to variety should be determined for these factors.

Processing and Cooking Characteristics

Basic studies to determine the role of each constituent of the rice kernel in processing and cooking behavior are needed. As these properties are defined, techniques should be developed so that breeding lines can be evaluated for these factors. This is an important part of the breeding program and is a prerequisite to developing types needed to meet all processor and consumer needs.

Specific Breeding Objectives

1. Develop varieties with high protein content.

2. Develop an improved medium-grain variety for California.

3. Develop cold water tolerant short- and medium-grain varieties for California.

4. Develop short-season long-grain varieties adapted for California and the Southern rice area.

5. Develop varieties resistant to the prevalent races of blast.

Information on Varieties and Source of Breeders' Seed

Rice breeders are responsible for information on performance of rice varieties and for maintaining breeders' seed of recommended varieties developed by state and federal agencies.

PROCESSING, COMPOSITION, AND NUTRITION

D. F. Houston, Leader, V. R. Williams, H. W. Schroeder, R. E. Ferrel, J. T. Hogan, and T. Wasserman

The panel notes progress being made in basic research on rice composition and physical properties, and recommends that such fundamental research be vigorously continued and expanded. More detailed information should be obtained on the composition and properties of the individual proteins, starches, and lipids present in the kernel, on their distribution in white and parboiled rices, and on changes associated with aging. Studies are needed on the changes occurring in these constituents--and in accompanying minor ones--when the protein contents of rice are increased in order to furnish a basis for determining improvements in cooking and processing techniques and in nutritional properties.

Additional information should be obtained on the enzymes of rice to utilize favorable actions and to inhibit undesirable ones, particularly in the preparation of special purpose rice foods. Studies should be continued on the relation of rice composition to agronomic, cultural, and storage practices, to related microbiological effects, and to genetic factors where this becomes possible. Information should be sought on the nature of the bonding of the bran to the endosperm.

The panel also recommends continued emphasis on application of basic information to improvement of present processing techniques and development of new ones. Attention should be given to preparation of special purpose rice fractions and concentrates, such as flours with high protein content, and to provision of equipment and processes for their production.

Research should also be started on corresponding low-protein rice as high calorie natural foods for dietary management of certain metabolic diseases such as phenylketonuria. Efforts should be directed towards development of further convenience foods in which rice is a main item, and towards new food processes which may involve malting, fermentation or other modifying action. Study should be made of special-purpose foods such as those for infant or geriatric feeding. Attention should also be given to production of light-colored, bland, parboiled rice. The changes that take place during cooking of rice should receive detailed study.

The panel further recommends that increased attention be given to maintaining and improving the nutritional values of rice and processed rice products. Studies should be continued in developing new and improved processes for coating rice and for enriching it in a rinse-resistant manner. The exploration of possibilities for increasing nutritional values in specially prepared rice fractions should be continued.

The panel recommends that in the foregoing fields, continued effort be made to develop objective test methods that will more accurately measure cooking and processing characteristics, and to reach agreement on standardization of methods.

The panel notes the valuable program of translating Japanese rice literature into English that is now in progress at the International Rice Research Institute, and recommends that the possibilities of making these translations available to rice researchers generally, and the means of financing their distribution, be explored.

RICE DISEASES

J. G. Atkins, Leader, and H. A. Lamey

Research studies, both basic and applied, are necessary for developing better control measures for rice diseases. Some of these studies should be in cooperation with specialists in other research fields for maximum progress. That is, a "team approach" should be used.

Blast

Current studies, which should be continued, include

(1) monitoring the pathogenic races of Piricularia oryzae in the Southern Rice Area;

(2) development of better differentiating varieties;

(3) cataloguing the U.S.D.A. rice collection for reaction to each pathogenic race;

(4) testing new selections for resistance; and

(5) mode of inheritance of reaction to specific races.

Progress has been made in developing new rice varieties with resistance to the major or prevalent races. These studies need to be continued in cooperation with the rice breeders using crosses made specifically for blast resistance. Fungicides should be tested for control of leaf and panicle blast.

Hoja Blanca

Basic studies should be continued to complete our knowledge on this disease, particularly nature of resistance, mode of inheritance of reaction in rice, and properties of the virus. The hoja blanca testing program should be continued until long-grain varieties have been released.

Straighthead

Sources of resistance and a simple testing technique are available for breeding rice varieties for straighthead resistance. These tests should be continued so that only resistant varieties are released. Several new varieties with straighthead resistance have been released.

Stand Establishment

Fungicides have been recommended for treatment of both drilled- and water-seeded rice. However, poor stands are sometimes encountered even with fungicides. Additional studies are needed to evaluate new chemicals and to more fully evaluate the several factors involved in stand establishment of water-seeded rice. Compatibility studies should be continued with the fungicide-insecticide combinations.

Kernel Smut

Studies should be continued on kernel smut to establish its host range and life cycle, and to develop suitable inoculation techniques for determining sources of resistance and for evaluating progeny of crosses for varietal reaction.

Head Blight

The relationship of Helminthosporium oryzae, Fusariun spp., Curvularia spp. and other fungi as well as environmental conditions to head blight should be determined.

Varietal Resistance

The cooperative testing and breeding program with the rice breeders should be continued for developing new disease-resistant rice varieties. Emphasis should be given to combining resistance to hoja blanca, blast, and straighthead.

INSECT CONTROL

T. R. Everett, Leader, C. C. Bowling, J. B. Baker, H. A. Lamey, R. D. Hendrick, A. A. Grigarick, M. D. Pathak, T. Nishida, A. Saldarriaga, and W. H. Lange

In the following recommendations the panel on insect control has attempted to point out areas for research which are directed at problems both immediate and long term. No attempt has been made to place the recommendations in order of priority of importance.

Investigations on all rice field pests should consider the possibility of utilizing biological agents or cultural practices to obtain control; or integrating these agents or practices with chemical control to cause the least disruptive action on the desirable species associated with rice fields.

The rice field, while man made, has become an important habitat for many wildlife species and whenever possible these species should be preserved.

Rice Stink Bug

1. More intensive studies should be conducted to determine what infestation levels are economically important.

2. Studies of the biology and ecology of the Tachinid fly Beskia aelops (Walker), which is parasitic on adults, and two species of Hymenoptera, Ooencyrtus anasae (Ashm) and Telenmous podisi (Ashm), which are parasitic on rice stink bug eggs.

3. Continued evaluation of insecticides and their effect on the stink bug populations and on natural parasites of the rice stink bug.

4. Continued studies on ecology and biology of the rice stink bug.

Rice Water Weevil

1. Continued studies on the biology and ecology and economic importance of this insect.

2. Continued evaluation of insecticides to be used as seed treatment and other methods of control.

3. Laboratory work to establish dosage mortality lines for currently used insecticides on this insect. This will enable workers at a future date to determine if resistance has developed.

Grape Colaspis

1. Continued studies on the biology and ecology of the insect, especially in relation to the effect of cropping and management practices on abundance and control.

2. Quantitative surveys to define the area in which this insect is a pest.

Leafhoppers and Plant Hoppers

1. Determine if any of the native species are of economic importance on rice.

2. Continue surveys and inspections to detect infestations of *Sogata orizicola* (Muir).

3. Continue investigations on possible alternate hosts for virus and vector.

4. Continue investigations on biology and ecology of *S. orizicola* with respect to control.

5. Maintain suitable colony of S. orizicola for use in a screening program, to select hoja blanca resistant rice varieties.

Stemborers

Conduct inspections and surveys to detect infestations of exotic species.

Armyworms

1. Develop methods of predicting peak of abundance.

2. Evaluate damage from these insects to the rice plant in various stages of growth.

3. Screen insecticides for control of this insect.

Grasshoppers

Determine the economic importance of the various species found in rice fields.

Rice Leaf Miner

1. Water management in relation to infestation.

2. Continue investigations of currently recommended and potential insecticides with respect to pest control, selectivity, and longevity in the soil, plants or the food chain of wildlife involved with rice fields.

Tadpole Shrimp

1. Conduct further studies on infestation levels in relation to seedling drift and muddy water.

2. Determine methods of sampling populations.

3. Continue evaluation of pesticides for their control.

Crayfish

1. Study the biology and ecology of the burrowing species of crayfish causing damage to irrigation systems in rice fields.

2. Conduct laboratory and field evaluation of pesticides for control of crayfish in rice fields and the relationship of these pesticides to other wildlife.

Insecticide-herbicide Compatibility

Determine the compatibility of insecticides to herbicides in relation to time of application and cultural practices.

CULTURAL PRACTICES, FERTILIZERS AND SOILS, PHYSIOLOGY, WEED CONTROL AND AGRICULTURAL EQUIPMENT

D. S. Mikkelsen, Leader, J. Antognini, V. L. Hall, J. H. Lindt, Jr.
F. J. Peterson, G. A. Place, R. J. Smith, Jr., E. A. Sonnier,
S. Sujadl, and W. A. Williams

The panel recommends that basic research should be expanded and applied work continued on the following problems:

Cultural Practices

1. Continue studies of crop and soil management problems unique to rice lands, including alternate crop opportunities for land use.

2. Identify factors contributing to poor stand establishment of rice and develop remedial cultural practices.

3. Accelerate studies of water management in rice as they influence yield weed control, fertilizer, and pesticide practices, water quality and water-use efficiency.

4. Initiate research toward the development of biological controls of rice insects, diseases, and weed pests.

5. Study problems of pesticide residues in soils, water, and the crop in respect to pesticide usage.

6. Improve methods to increase the over-all efficiency of ratoon cropping of rice.

7. Continuous improvements in harvesting practices for maximum recovery and yield of quality rice.

Fertilizers and Soils

1. Develop improved fertilizer practices which will give high yields of quality rice at low unit production costs.

2. Accelerate development of soil and plant analysis techniques for quick evaluation of the fertilizer needs of rice.

3. Increase basic research on the physico-chemical changes occuring in flooded soils as they influence the growth of rice and continued productivity of the soil.

4. Increase research emphasis on soil problems associated with the various physiological diseases occurring in rice.

5. Study problems of soil alkalinity and salinity as well as water quality as it influences the growth of rice and rotation crops.

Weed Control

1. Continue to evaluate new chemicals for control of broad-leaved weeds, with special emphasis on reducing injury to rice and adjoining crops.

2. Continue studies on the chemical control of grasses and red rice in conjunction with other cultural practices.

3. Investigate the effect of herbicidal practices on the ecology of weeds and their growth in rice or alternate rice rotations.

4. That additional work be done on control of submerged aquatic weeds in rice fields and irrigation systems.

5. That an industrywide cooperative program be developed to determine the losses of yield and quality due to rice weeds.

6. Expand basic research on the uptake, movement, metabolism, and fate of herbicides in rice and their fate in water and soil.

Physiology

1. More basic research should be initiated to determine the effect of environmental factors, such as light, temperature, humidity, water depth, nutrition, and biotic relationships on the physiology and yield components of rice.

2. Initiate research in cooperation with plant breeders to develop plant types which have the greatest yield and quality potential for specific climatic areas.

3. Study the effect of micro and macro climate on the morphological development of the rice plant and their effects on yield and quality of rice.

4. Continue and expand research on the physiology of rice under different conditions of water management including cold water conditions.

5. Investigate the possible use of growth regulating chemicals to alter rice plant growth for highest possible yield and quality benefits.

Agricultural Equipment

1. Continue to evaluate and improve equipment for aerial application of seed, fertilizers, and pesticides.

2. Accelerate engineering studies toward improved design of existing ground equipment, with special emphasis on precision seeding and fertilizer placement, and improved harvesting equipment for use under wet soil conditions.

RICE DRYING AND STORAGE

D. L. Calderwood, Leader, Macon Faulkner, Finis Wratten, Theodore Wasserman, Lloyd Johnson, Robert Cogburn, Isamu Yamanka, and Franasio A. de le Rosa

1. Studies be initiated to

   (a) establish a fundamental mathematical formula for drying rice,

   (b) analyze stress and strains developed during the drying of rice, and

   (c) study inter-relations between strains, fissure development, moisture content, and other physical parameters.

2. Continue research on drying procedure using continuous flow, heated air dryers:

   (a) full scale, and

   (b) laboratory.

3. Studies be investigated on new methods, techniques, and equipment for drying rice.

4. Develop methods for drying rice samples without changing milling yield.

5. Study the effect of drying procedure upon the cooking characteristics and chemical composition of rice.

6. Study the handling of rough rice during drying at commercial dryers to determine operating methods and drying techniques used, the labor requirements for drying rice, and the operating and equipment costs.

7. Study aspects of bulk handling of milled rice.

   (a) maintaining quality in bulk storage,

   (b) breakage due to conveying and dropping,

   (c) breakage due to changes in temperature and humidity

8. Continue studies of methods of determining quality characteristics of rough and milled rice by objective measurements.

9. Re-emphasize need for study to determine better methods, techniques, and equipment for milling rice.

10. Make a re-evaluation of physical properties of rice such as static pressure characteristics, angle of repose, and true and apparent densities of different moisture content rice, and that information on physical and chemical constants be brought up-to-date and published in a handbook.

11. Studies on fumigation, protectants, and other methods of inhibiting the spread of stored grain insects in rough and milled rice be continued with emphasis on methods which have few or no chemical residue problems.

12. That storage tests of coated rice, both enriched and unenriched, be conducted to determine the relative resistance to insect infestations in comparison with that of uncoated rice.

13. Initiate research to investigate the biology and ecology of stored grain insects. The effects of photoperiod and changes of the micro-environment of these insects should be included in these studies.

ECONOMICS AND MARKETING

Troy Mullins, Leader, Robert A. Bieber, Leonard B. Ellis, Stanley S. Johnson, Marshall E. Miller, and Harlan D. Traylor

In developing these suggestions the panel gave particular attention to the recommendations pertaining to rice included in the recent report of the research advisory committee on grain and forage crops.

1. In view of changes taking place in production techniques, and the persistent trend toward larger farm units, continued effort should be made to develop accurate statistics which reflect the effects of those changes on production costs, labor requirements, and the number of farm units. At the state and area level cost-of-production studies on rice and on computing crops are needed to aid farmers in determining the most profitable combinations of enterprises, when the year-to-year changes in cost factors and in prices received are taken into account.

To aid in formulation of policy objectives relating to total U.S. production, the aggregative effects of adjustments in resource use should be determined.

2. Special (short-run) studies should be made to assist farmers in evaluating new practices that show promise of being profitable on representative farms in major rice areas.

3. A third general area on which research is needed is the increased capital required to adequately equip farms for effective operation. The high capital requirements of current operations increase importance of risk associated with yield variability and/or changes in other factors that influence profit.

4. Foreign market research should be continued to determine the potentials for the sale of U.S. rice in the principal rice importing areas of the world, particularly in those areas where dollar markets are opening up. Marketing methods and practices in the new independent countries should be studied to determine their distribution requirements in terms of type of packaging, and other related factors, as well as variety and the quality of rice desired. In addition research is needed to determine the feasibility of the shipment of rice in bulk, particularly the shipment of milled (white) rice.

5. Research should be expanded and intensified to develop more reliable and accurate methods for use in grading rice. In addition to research for determining the degree of milling, color, and cooking quality, research should be initiated to determine practical grades for brown rice to be exported as cargo rice in competition with cargo rice from other areas.

6. Research should be continued to measure periodically rice distribution patterns in the domestic market to establish trends in market size and to delineate changes in market location. More emphasis should be placed on evaluating the factors associated with market changes to guide industry marketing decisions. A particular factor, the emergence of a number of new rice products, should be studied to determine impact on demand and whether their products represent market gains or substitutes for existing rice products.

TIMING NITROGEN FERTILIZATION OF RICE WITH THE MORPHOLOGICAL DEVELOPMENT OF THE PLANT

Vernon L. Hall [1]

From greenhouse to field studies, properly timed midseason nitrogen topdressing has increased the yeild of rice in Arkansas. It appears that the best guide for proper timing would be to associate the plant development with the desirable plant response to fertilization.

Nato rice was grown in the greenhouse and fertilized at weekly intervals during the midseason. Some plants were harvested for a morphological study while others were allowed to mature. None of the plants were fertilized more than once.

At 63 days and after (table 1) the main stems required less time, while the tillers required more time, from planting to emergence.

The number of tillers was about the same, but there was an increase in the differentials between panicle emergence of tillers and that of the main stem (table 2). The tillers on the 84-day plants were so late they were not harvested.

Table 1. --Panicle emergence in days from time of planting per plant average of four replications

Plant age	Main stem	Tillers	Main stem & tillers
Days	Days	Days	Days
42	101	103	102
49	102	105	103
56	101	106	104
63	94	113	103
70	96	115	105
77	94	117	105
84	95	0	95

Table 2. --Number of tillers per container, differential panicle emergence between tillers and main stems, and percent of the total florets on the main stems, average of four replications

Plant age	Tillers per container	Delay of tiller emergence	Florets on main stem
Days	Number	Days	Percent
42	5	2	55
49	8	3	44
56	8	5	49
63	7	19	42
70	7	19	45
77	7	23	65
84	9	--	100

The largest number of florets on the main stem was at 56 days while the maximum for the tillers extended over both 56 and 63 days. The 56-day plants produced the greatest total number of florets (table 3).

Table 3. --Number of florets per container, average of four replications

Plant age	Main stem	Tillers	Total main stem and tillers
Days	Number	Number	Number
42	422	343	765
49	416	530	946
56	563	593	1156
63	439	600	1038
70	377	461	838
77	401	220	620
84	289	0	289

1/ Assistant agronomist, Department of Agronomy, University of Arkansas, Fayetteville, Ark.

When considering both the differential maturity between tillers and main stem, and the total florets formed, the 56-day plants were the most desirable.

The main stem internode between the 5th and 6th node was chosen as the morphological indicator of the plant development. The maximum and minimum internodal lengths are for single plant samples while the average is calculated from 12 to 16 plants (table 4).

It appears that at least 10 plants should be examined and the minimum, maximum, and average elongation be considered in evaluating the stage of development of a field of rice. It appears that the maximum elongation of two millimeters would be a key to the correct time for application of midseason nitrogen to Nato rice.

One year's information from a cooperative field study with Dr. John Sims at the Rice Branch Experiment Station substantiated the greenhouse information for Nato rice. Bluebonnet 50, a midseason variety, was quite uniform but slightly shorter than Nato. Vegold, a very early variety, had an extremely wide variation in internodal elongation.

It appears that both the early and midseason varieties of rice offer good possibilities to estimate the timing of nitrogen topdressing by the morphological development of the rice plant.

Table 4.--Internodal measurements between the 5th and 6th nodes of the main stems

Plant age	Minimum length	Maximum length	Average length
Days	Mm.	Mm.	Mm.
42	0.5	1.7	0.8
49	1.1	1.6	1.4
56	1.4	1.8	1.6
63	0.7	2.8	1.7
70	2.0	18.0	10.0
77	13.0	77.0	48.3
84	30.0	83.0	58.3

THE INFLUENCE OF LIGHT INTENSITY AND NITROGEN FERTILITY ON RICE YIELDS AND COMPONENTS OF YIELD [1/]

J. W. Stansel, C. N. Bollich, J. R. Thysell, and V. L. Hall [2/]

From 1961 through 1963 we conducted field experiments to determine the influence of light intensity and nitrogen fertility on yield and the components contributing to yield.

During 1961-62 at Stuttgart, Ark., Biggs, Calif., Crowley, La., and Beaumont, Tex., treatment combination consisted of 0, 60, and 120 pounds of nitrogen per acre at three light levels (100, 70, and 40 percent daylight intensity). Light intensities were controlled by the use of saran cages of known light penetration. In the Southern States, Bluebonnet 50 was the test variety in 1961, and Belle Patna in 1962. In the test conducted at Biggs, Calif., in 1961, the test variety was Calrose.

As light intensity was reduced, grain yield was lowered at all nitrogen rates (table 1). Light intensity also had an influence on the amount of nitrogen to be utilized for grain yield within each light level. Maximum yields from high rates of nitrogen were exhibited only under maximum light conditions. When light was reduced to 70 percent, the intermediate nitrogen rate produced the highest yields. When light was reduced to 40 percent, the application of 60 pounds of nitrogen did not increase yields, and 120 pounds of nitrogen reduced yields. Therefore, light intensity had a direct influence on grain yield and determined the optimum level of nitrogen fertility to be utilized for grain yields.

Table 1.--Rough rice yield (pounds/acre) at different daylight intensities and nitrogen fertility for all locations during 1961-62

Item	Nitrogen (lbs./acre) 0	60	120	Light treat $\bar{x}$
Light intensity level, 100 percent	3216 a	4081	4485	3928
Light intensity level, 70 percent	2736	3336 a	3120 a	3064
Light intensity level, 40 percent	1833 bc	1892 b	1519 c	1748
Nitrogen treat $\bar{x}$	2595	3103 a'	3041 a	

Numbers followed by the same letter do not differ significantly at the 1-percent probability level, using Duncan's sequential test of means.

1/ A cooperative study conducted by the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture and the Agricultural Experiment Stations of Texas, Arkansas, California, and Louisiana.

2/ Assistant geneticist, Texas Agricultural Experiment Station; research agronomists, Crops Research Division, Agricultural Research Service, U.S.D.A.; and Assistant Agronomist, Arkansas Agricultural Experiment Station, respectively.

The yield response to nitrogen and light treatments was similar for all three varieties tested, from four widely divergent locations, over a two-year period. These results suggest that light may influence nitrogen response for many varieties over a wide range of environments.

To define the important components of yield, a multiple regression model was derived from the 1962 data. Full florets per panicle, the interaction of panticles per unit area X panicle weight, and the number of seedlings per unit area accounted for 88 percent of the yield variability of the 1962 test.

It was found that low light intensity reduced yield by lowering the number of full florets per panicle, individual kernel weight, and the number of panicles per unit area. Increased rates of nitrogen increased the full florets per panicle except under reduced light intensity. High nitrogen levels lowered 1, 000-kernel weight, but had no influence on panicles per unit area.

Tests were conducted in Arkansas, Louisiana, and Texas in 1963 to determine if reduced light for shorter periods of time and during different stages of plant development influenced yield. The following were the light intensity treatments:

Control--100 percent daylight for the entire growing period

Stage 1--40 percent daylight from seedling emergence to tillering

Stage 2--40 percent daylight from tillering to panicle differentiation

Stage 3--40 percent daylight from panicle differentiation to heading

Stage 4--40 percent daylight from heading to maturity

Nitrogen treatments were 60 and 120 pounds per acre, and Belle Patna was the test variety.

Results from the 1963 test indicate that the later light intensity is reduced in the life cycle of the plant, the larger the reduction in grain yield will be (table 2). Reduced light during any of the last three stages of growth at the 120-pound nitrogen rate reduced yields about the same. This again indicates that light influences optimum nitrogen utilization for grain yield. Extended periods of cloudy weather during the later stages of plant development, and especially during shorter days late in the season, may be very important in limiting yield.

Low light levels during Stage 2 reduced tillering, especially at the high nitrogen rate, resulting in a reduced number of panicles per unit area. Low light levels during Stages 3 and 4 further reduced grain yield by lowering the number of full florets per panicle. While 1, 000-kernel weight was not statistically influenced by light intensity, we believed that low light must also have limited 1, 000-kernel weight. Other factors being equal, increased kernel weight should be expected when full florets are reduced.

Nitrogen fertility increased the number of full florets per panicle but reduced 1, 000-kernel weight so panicle weights did not change. Also, nitrogen levels had no effect on the number of panicles per unit area. Since neither panicle weights nor panicle number were influenced by nitrogen levels, no response was evident for yield.

Light seems to have a direct influence on the amount of nitrogen fertility that can be utilized for maximum grain production. As the plant grows and develops, light becomes increasingly important in determining grain yields.

Table 2. --Rough rice yield (pounds/acre) from reduced daylight intensities at different stages of plant development for all locations during 1963

Item	Nitrogen (lbs. /acre)		Light
	60	120	treat $\overline{x}$
100 percent light (control)	4231 ab	4579 a	4405 a'
40 percent light--stage 1	4602 a	4798 a	4700 a'
40 percent light--stage 2	3999 ab	3055 c	3527 b'
40 percent light--stage 3	3549 bc	3155 c	3352 b'
40 percent light--stabe 4	3096 c	3188 c	3107 b'
Nitrogen treat $\overline{x}$	3895 c'	3741 c'	

Numbers followed by the same letter do not differ significantly at the 1-percent probability level, using Duncan's sequential test of means.

ORGANIC SOURCES OF NITROGEN FOR RICE

W. A. Williams[1]

Recent investigations into the use of farm-grown organic sources of nitrogen in rice culture at the California Rice Experiment Station have emphasized two types of materials:

(1) High-nitrogen containing materials and

(2) low-nitrogen containing materials.

The high-nitrogen materials are typified by vetch grown as a green manure crop during the winter season. Abundant evidence has been accumulated which shows that vetch containing 3 to 4 percent nitrogen, as it normally does at plow-down time, is a highly effective and often inexpensive source of nitrogen for the succeeding rice crop. If it is properly covered in the seedbed to achieve an average depth of about 4 inches, it is equal on a pound-for-pound nitrogen fasis to the best chemical source of nitrogen placed in the most effective position in the soil.

How much nitrogen does a legume green manure crop supply for the subsequent rice crop? A grower must have an answer to this question in order to decide on an appropriate fertilizer program for the crop following green manuring. The answer depends on the amount of plant material to be turned under and its nitrogen content. The results of a number of green manure trials involving vetches (Vicia spp.) and peas (Pisum sativum) have been analyzed, and a rule has been developed for estimating the available nitrogen named RULE-16 to estimate the available nitrogen turned under is as follows:

1. Harvest several 4 x 4 ft. areas of the legume which are representative of the field being sampled.

2. Determine the average number of pounds of fresh material per 4 x 4 ft.

3. Multiply by 16 to obtain pounds per acre of available nitrogen.

EXAMPLE:

(3. 5 lbs. fresh weight per 4 x 4 ft. area) x 16 = 54 lbs. N/acre.

This rule applies to vetches and peas at the time they are usually turned under:

Vetches--prebloom to early bloom;

and peas--full bloom.

The value of low-nitrogen containing organic materials as sources of nitrogen is of immediate interest because all cereal residues, including rice crop residues, fall in this category. Typically the nitrogen content of rice residues is approximately 0. 5-0. 6 percent (dry basis) although there is considerable variation. The volume of such material produced with current practices in California is very sizable. This can be readily appreciated by applying a 1. 25 grain-straw ratio to grain yields which are frequently in the neighborhood of 60 cwt. /acre and occasionally up to 80 cwt. /acre. (State average for 1963 was 48. 5 cwt. /acre.) If such material is incorporated in an upland soil and a row crop grown under aerobic soil conditions, we will expect, based on wide experience, that nitrogen tie-up will occur during decomposition of the crop residues. Under such conditions most materials containing less than 1. 5 percent nitrogen can be expected to make available very little nitrogen during the current growing season after incorporation.

However, the results of experiments conducted in the past two seasons indicate that the the situation is quite different in the presence of the anaerobic conditions existing in flooded rice soils. Preliminary data on the

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breakdown of rice straw under field conditions indicate that there can be mineralization of organic nitrogen contained in rice straw. That this nitrogen is available to current rice crop has been substantiated by increased yields on straw-treated plots relative to no-straw plots. As one would expect the degree of nitrogen release is associated with the nitrogen level in the straw. Residues with relatively high nitrogen contents, e. g., 0.65 percent N, have shown positive nitrogen availability and yield response in rice. Whereas, low-nitrogen residues, e. g., less than 0.5 percent N, have released no nitrogen or even caused nitrogen tie-up as indicated by the response of rice yields and nitrogen recovery by the crop.

Nonetheless, the contrast with the results from crop residues under upland conditions is very striking. As more knowledge is gained relative to the effects of the increasing amounts of crop residues from the larger crop resulting from improved rice growing technology, a reassessment of our crop-residue management practices will be in order.

RESPONSE OF RICE TO PHOSPHORUS FERTILIZER AT CONTROLLED LEVELS OF SOIL PHOSPHORUS

F. J. Peterson[1/]

Soils of southwestern Louisiana are exceptionally low in phosphorus, ranging from 3 to 20 p. p. m. as determined by the Louisiana State University soil testing laboratory. A field experiment was designed to measure the response of rice to applications of phosphorus fertilizer at levels of soil phosphorus greater than 3 to 20 p. p. m.

Four levels of soil phosphorus were established at the Louisiana State University Rice Experiment Station on Crowley silt loam during 1959 by applying 0, 92, 184, and 368 pounds per acre of P_2O_5 as triple superphosphate. The addition of triple superphosphate during 1959 caused a linear increase in soil test values from 10 to 65 p. p. m. available phosphorus as determined by a soil test from each plot during 1962 and 1963.

The response of rice to 0, 25, and 50 pounds per acre of P_2O_5 was measured at each of the four levels of soil phosphorus. A 2-year average (1962 and 1963) indicates that the application of 92 pounds per acre of P_2O_5 during 1959 brought about an increased response of rice to applications of phosphorus fertilizer at planting. The higher levels of soil phosphorus (184 and 368 pounds per acre) seemed to decrease the response of rice to applications of phosphorus fertilizer at planting.

1/ Assistant professor of soils, Rice Experiment Station, Louisiana State University, Crowley, La.

RED RICE INVESTIGATIONS

Earl A. Sonnier[1/]

Red rice is one of the most troublesome noxious weeds confronting producers of rice for seed and for milling purpose in Louisiana. A recent survey indicates that the major rice field weeds cause annual discounts of approximately \$1.733,000 in rice purchased for milling. Red rice is responsible for discounts of \$1,421,000 which is approximately 82 percent of the total.

While such findings reflect the Statewide situation, there is little information by which individual farm or producer losses can be assessed. The research summarized herein is directed toward more accurate determination of processing losses and to better understanding of the red rice plant.

Milling Studies

Milling experiments have been conducted which were designed to measure the effects of specific quantities of red rice upon head rice yield, total mill yield, grade, and support price of Nato and Bluebonnet 50 rices.

Rough red rice was introduced into samples of uncleaned Nato and Bluebonnet 50 rices in quantities ranging from 0 to 20 percent by weight. The samples of domestic rice were drawn from foundation seed stocks. Milling and grading were done in accordance with methods prescribed by the Federal Rice Inspection Service. Price support rates were calculated by applying the schedule of value factors, premiums, and discounts issued annually by the Agricultural Marketing Service to the data obtained in the milling experiments.

Head and total mill yields of both Nato and Bluebonnet 50 varieties declined as red rice content of the rough rice sample increased. For any level of red rice, however, the head yield of Bluebonnet 50 was more severly reduced than was that of Nato. Total mill yields of the domestic rices were only slightly affected by the introduction of red rice.

The presence of 8 percent red rice in the original sample reduced the loan value of Nato rice from \$5.02 to \$4.33 per hundredweight. Greater concentrations of red rice caused the rice to fall in grade U.S. No. 6 which is ineligible for loan.

The presence of 12 percent red rice in the original sample reduced the loan value of Bluebonnet 50 rice from \$5.46 to \$4.62 per hundredweight. Additional red rice in the sample rendered it ineligible for loan.

Date-of-Seeding Experiment

A date-of-seeding experiment was instituted in 1963 for the purpose of comparing length of growing season and other growth characteristics of red rice with those of two commercial varieties grown under similar field conditions.

The varieties used were Nato, Bluebonnet 50, strawhull red rice, and blackhull red rice. Seeding dates were April 5, May 16, June 11, and July 11. One hundred seeds of each variety were planted in rows at 1-inch spacing. A basal fertilizer application of approximately 60-30-30 was made prior to planting.

There was a decrease in the interval from seeding to the appearance of first heads for all four varieties in the April, May, and June seedings. A slight retardation occured in all four varieties in the July seeding.

The heading data reveal distinct differences in the growing season of strawhull

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and blackhull red rices. The growing season of strawhull red rice corresponds very closely to that of Nato, while the growing season of blackhull red rice is more nearly like that of Bluebonnet 50. In each case, however, the red rices begin heading 3 to 5 days earlier than the corresponding cultivated varieties.

Viability Study

An experiment was initiated in 1962 for the purpose of studying the germination characteristics of red rice seeds at different stages of maturity.

Five-hundred red rice panicles of the strawhull type were tagged on the day when completion of heading occured. Seed samples for germination tests were harvested daily between the fourth and twenty-third days thereafter.

The seed samples were stored for a period of approximately 7 months. The seeds were germinated and the results interpreted according to methods outlined in Rules for Testing Seeds[2/].

Normal seedling counts ranged from 1/2 percent at 4 days (maturity) to approximately 70 percent at 23 days (maturity). Dormant seeds occurred in each daily increment except day groups 4 and 5.

2/ Rules for Testing Seeds, Assn. of Official Seed Analysts, 1960.

EFFECTS OF WEED COMPETITION ON RICE [1/]

Roy J. Smith, Jr.[2/]

The competitive effects of barnyardgrass (Echinochloa crusgalli (L.) Beauv.), sesbania (Sesbania exaltata (Raf.) Cory), curly indigo (Aeschynomene virginica (L.) B.S.P.), and ducksalad (Heteranthera limosa (Sw.) Willd.) on quality and yield of rice (Oryza sativa L.) were investigated in field experiments.

Barnyardgrass is a serious weed problem in all rice-growing areas of the United States. Barnyardgrass reduced rough rice yields 18 and 36 percent on plots with one and five grass plants per square foot, respectively, and with an optimum stand of rice. The grass-free plots yielded 5, 350 pounds rough rice per acre. Barnyardgrass was more competitive with rice on plots with thin stands of rice than on those with optimum stands.

Where barnyardgrass competed with rice for 9 days after its emergence, was removed by hand weeding, and was kept out thereafter, plots yielded 4, 610 pounds per acre of rough rice. Grass on these plots was removed when it had 1 to 3 leaves or about the time 3, 4-dichloropropionanilide (propanil) would normally be applied. These plots were used as the standard treatment. Where barnyardgrass competed with rice for16 and 23 days after its emergence, or 7 and 14 days beyond that of the standard treatment rice yields were reduced, about 17 percent compared to the standard treatment.

Sesbania and curly indigo are serious weeds in rice in the southern United States. In a 2-year study yields of rice were reduced 2, 4, 9, and 19 percent on plots where sesbania competed with rice for 4, 8, 12, and 15 weeks after weed emergence, respectively. Yields of rough rice from weed-free plots were 5, 710 pounds per acre. Sesbania populations of 5, 445, 10, 890, 21, 780, and 43, 560 plants per acre reduced yields of rice 8, 14, 26, and 39 percent, respectively, in a 3-year investigation. Weed-free plots in this experiment 5, 520 pounds of rough rice per acre. Rice fields often contain 10, 000 to 50, 000 sesbania plants per acre. Similar studies were conducted with curly indigo.

Ducksalad, a serious aquatic weed in rice, reduced rice yields an average of 5, 14, 28, and 21 percent in a 5-year investigation when competition was for 2, 4, and 8 weeks after weed emergence and for all season, respectively. Weed-free plots yielded 5, 220 pounds of rough rice per acre.

1/ Cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the Arkansas Agricultural Experiment Station.

2/ Agronomist, Crops Research Division, Agricultural Research Service, U.S.D.A., Stuttgart, Ark.

TIME OF TOPDRESS NITROGEN APPLICATIONS ON RICE

John L. Sims[1/]

Field tests were conducted on Crowley silt loam soil during the years 1961 and 1962. The experimental areas used had been in rice-soybean-oats rotations for several years. Factors studied included rice varieties of three different maturity groups, nitrogen rates of 75, 120, and 165 pounds per acre, and seven times of N fertilizer application. Times N application were all based on the number of days from seedling emergence and differed for each maturity group of rice. All applications were made topdress on dry soil and flood water was applied immediately. Each rate of N was applied in 1, 2, or 3 applications.

Equal grain yields (average of 3 N rates) for Nato rice were obtained; when N was applied:

(a) 1/2 at 14 and 1/2 at 58 days,

(b) 1/2 at 38 and 1/2 at 58 days, and

(c) 1/3 at 14, 1/3 at 38, and 1/3 at 58 days.

Lower values for plant height (3 inches less) and lodging percentage (10 percent less) were obtained when N was applied 1/2 at 14 and 1/2 at 58 days than when applied as either (b) or (c) above. Severe lodging in combination with delayed maturity, higher plant height, and lowered grain yields occurred when N was applied as a single application at 38 days.

Yields of grain from Bluebonnet 50 rice were significantly reduced (500 pounds per acre) when N was applied as a single application at 48 days. Approximately equal grain yields were obtained when equal amounts of N were applied in single applications at either 13 and 66 days or in split applications involving 13 and 66 days.

Highest grain yields in combination with moderate plant height and lodging were obtained with Vegold rice when N was applied 1/2 at 10 and 1/2 at 48 days. Less grain was obtained when N was applied in a single application at 10 days or when applied as a split application at 10 and 30 days. Values for plant height and lodging were also lower for the latter treatments.

Nitrogen applied to Nato and Bluebonnet 50 rice at the rate of 120 pounds of N per acre increased grain yields over the rate of 75 pounds. No further increases were obtained from an additional 45 pounds of nitrogen. Grain yields for Vegold rice were 500 pounds per acre higher when fertilized at the 165 pound N rate than when fertilized at the 120 pound N rate.

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CHOICE OF INDEX LEAF FOR DIAGNOSING THE N STATUS OF RICE

E. F. Wallihan[1/]

Leaf samples of three varieties of rice (Peta, FB 121, and PBI 76) were taken at weekly intervals to determine the most suitable leaf for N analysis, based on two criteria:

1. Stability of N concentration at the time sample is taken;

2. Responsiveness to differences in N supply.

Of the various stages in development that might be designated for taking samples, appearance of flower primordia and flower emergence were considered most suitable. It appears that either time might be chosen, but the period of flower emergence is most easily identified by inspection.

The data show that in all three varieties the next to the last leaf formed (which may be called the "Y" leaf if one designates the terminal leaf as "Z"), sampled at the time of 50 percent flower emergence, is most stable with respect to N concentration of the top four leaves. The Y-leaf also was more sensitive to N supply than the Z-leaf and equally sensitive to the X- and W-leaves.

1/University of California, Riverside

Study conducted at the International Rice Research Institute in the Philippines, in cooperation with J. C. Moomaw, agronomist.

RICE WEED CONTROL IN CALIFORNIA WITH R-4572

J. Antognini[1]

Introduction

R-4572, Ordram[2], (S ethyl hexahydro-1H-azepine-1-carbothioate) is undergoing its third year of extensive field testing in rice in California. In 1962 and 1963 it was tested under the code number of R-4572. This compound possesses a low order of toxicity to mammals with the acute oral LD-50 of the technical material on rats being 720 mg./kg. The acute dermal LD-50 of the technical to albino rabbits is greater than 2,000 mg./kg. On fish the LC-50 value of the technical material for the three spined stickleback is 13 p.p.m.

In 1962 and 1963, trials were applied throughout the rice growing areas of California with most of the treatments being applied preplant soil incorporated by discing once. Each year one test was conducted where no incorporation was done but the area was flooded within 12 hours of application. In 1962 the 6 lb. per gallon emulsifiable concentrate formulation was used and in 1963 the 5-percent granular formulation was used. Rates tested ranged from 1 to 12 lbs. per acre.

Safety to Rice

Rice stands and growth were not injured in any California field test by the highest rate used, which was 12 lbs. per acre. Weed control was good to excellent at rates of 2 to 3 lbs. per acre. Rice tolerance to R-4572 in California is, therefore, in the range of 4 to 6 times greater than the tolerance of the weeds.

Weeds Controlled

Control of Echinochloa spp. and Leptochloa spp. was good to excellent in all trials at rates of 2 to 3 lbs. per acre. In the California trials, as well as trials in other States and countries, observations indicated that R-4572 is effective in controlling other grassy weeds and some of the broadleaf weeds present in rice.

Methods of Application

The two main methods of application used in the 1962 and 1963 tests proved to be effective. These were preplant soil incorporated and preplant non-incorporated. The soil incorporated treatments were harrowed or disced once within 2 hours after application with the interval to flooding ranging from 1 to 7 days. The non-incorporated applications were flooded within 12 hours after application. Trials in 1964 are designed to determine the maximum effective interval between application and flooding with non-incorporated applications.

A small-scale trial by the Rice Experiment Station showed that the granular formulation applied to the water surface 18 days after flooding resulted in excellent watergrass control with no injury to the rice. In tests overseas similar results were obtained when the emulsifiable formulation was sprayed on the water surface. In these tests the watergrass was just beginning to emerge from the soil at time of application.

1/ Agricultural Research and Development, Stauffer Chemical Company, Mountain View, Calif.

2/ Stauffer Chemical Company's trademark for an herbicide.

Yields

Yield data obtained in replicated trials at the Rice Experiment Station at Biggs, Calif., in 1962 by Viste[3] and in 1963 by Mueller[4] are summarized below. In these tests the material was applied preplant and not incorporated into the soil but flooding was done within 12 hours.

Average yield in pounds per acre of clean rice at 14-percent moisture

Lbs. of R-4572 per acre	1962 [1]	1963 [2]
1		3,160*
3	4,605	3,470**
5		3,350**
6	4,671	
0	3,850	2,540

1/ Average of 4 replications.

2/ Average of 5 replications.

* Significantly different from the check at 5-percent level. (LSD=590 lbs. per acre).

** Significantly different from the check at 1-percent level. (LSD=780 lbs. per acre).

3/ Viste, K. L.--Personal correspondence.

4/ Mueller, K. E. Annual Report. Rice Experiment Station, Biggs, Calif. 1963.

EFFECTS OF ROW SPACING, SEEDING RATE, AND HIGH NITROGEN FERTILIZER ON RICE YIELDS[1/]

John E. Scott[2/]

Following observations in 1962 of high yields from a plot of rice sown in widely spaced rows, a study of the effects of row spacing was initiated. Incorporated into the study were varieties, seeding rate, and fertilization.

Row spacings were 9 and 18 inches. With seeding rates of 40, 80, and 120 pounds per acre, the 18-inch spaced rows were seeded with twice the volume of seed per linear foot of row sown in the 9-inch rows.

Two fertilizer rates were applied. These were the recommended rate of 80-40-0 and a high nitrogen rate of 160-40-0.

Three varieties of midseason maturity were used. Bluebonnet 50 and C.I. 9444 are long-grain varieties similar in growth habit, producing a tall plant with long, broad leaves. C.I. 9545 is a medium-grain type of shorter stature with shorter, more narrow leaves. Under comparable conditions, it produces much higher grain yields.

Row spacings were found to have no statistically significant influence on yield. The number of tillers per square yard was reduced significantly in the 18-inch spacings, but a corresponding increase in panicle weight offset any appreciable reduction in yield. A decrease in total filled florets also occurred which, in turn, resulted in an increase in 1,000 kernel weight. This increase in kernel weights, therefore, was the factor responsible for increased panicle weight. A multiple regression analysis revealed that 78 percent of the yield was accounted for or contributed to panicle weight, plus the interactions of tillers x total filled florets and total filled florets x 1,000 kernel weights.

An increase in seeding rate from 80 to 120 pounds per acre reduced yields in Bluebonnet 50 and C.I. 9545 in both the 9- and 18-inch row spacings. C.I. 9444 reacted similarly in the 9-inch spacings, but in the 18-inch spacings there was a slight increase in yield in those plots that received 80 pounds of nitrogen per acre.

A larger number of tillers resulted from the increase in seeding rate, but panicle weight was reduced substantially in Bluebonnet 50 and C.I. 9545 which resulted in the loss of yield in these varieties. In the C.I. 9444 variety a reduction in panicle weight took place, but it was not as great a loss as that in the other varieties so more tillers in this instance gave an increase in yield.

Varietal differences became very apparent where additional nitrogen was applied to those plots with 18-inch row spacings. At both the 80 and 120 pound seeding rates, the medium-grain variety had a yield increase of approximately 400 pounds per acre. Yields of Bluebonnet 50 were reduced by approximately 600 pounds per acre. The loss of tillers in Bluebonnet 50 was too great to be offset by an increase in panicle weight as was the case with C.I. 9545. Only in those plots of Bluebonnet 50 with a 40-pound seeding rate did an addition of nitrogen result in an increase in yield.

The 40-pound seeding rate produced yields comparable to those of the 80- and 120-pound rates. Number of tillers per square yard was lowest in these plots, but any effect toward reduction of yield was overcome by very high panicle weights resulting from a combination of increased kernel weights and total filled florets.

1/ Cooperative investigations, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, Rice-Pasture Research and Extension Center of the Texas Agricultural Experiment Station, and the Texas Rice Improvement Association.

2/ Assistant agronomist, Rice-Pasture Research and Extension Center of the Texas Agricultural Experiment Station, Beaumont, Tex.

Reliable lodging results were obtained only on the C.I. 9545 variety. For this shorter plant type the wider row spacing appeared to have increased resistance to lodging. No lodging occurred in those plots that received but 80 pounds of nitrogen per acre. The higher nitrogen rate produced some lodging in all plots with seeding rates showing an influence. The 18-inch row spacings had 20 and 40 percent less lodging in plots of 80- and 120-pound seeding rates, respectively, where 160 pounds of nitrogen was applied.

RESPONSE OF RICE TO IRON COMPOUNDS ON ALKALI SOILS

D. S. Mikkelsen, W. G. Golden, and K. Ingebretsen[1/]

A chlorosis occurring in seedling rice, Oryza sativa, japonica, which may result in partial to complete loss of plants and crop failure, has been observed in California over a number of years. Because the syndromes usually appear where rice is grown on soils with excessive amounts of absorbed sodium, the condition has been called "alkali disease." Water-sown lowland rice is the only crop seriously affected since upland crops such as cereals, safflower, sugar beets, pasture, and alfalfa usually make satisfactory production. If both excessive absorbed sodium and salinity exist, production of all crops is impaired.

Water-sown rice in these alkali areas usually becomes clorotic as soon as the first true leaves are formed. The chlorosis, which is uniform over the entire plant, becomes increasingly severe with time. Eventually irregular dark necrotic spots develop on the leaves which are structurally weak and float on the water. Affected plants usually die some 4 to 6 weeks after planting and subsequently completely disintegrate in water. Rice production is usually a complete failure, but occasionally a few scattered plants survive which mature later than a normal crop in the area.

Field experiments have recently been conducted at various locations where the "alkali disease" problem was known to occur. Randomized block designs were used with individual treatments replicated on plots exceeding 1/100 acre in size. Various commercial iron compounds were broadcast at several rates on the surface of the prepared seedbed which had previously been uniformly fertilized with nitrogen or nitrogen-phosphorus applications. The iron compounds were broadcast because earlier experiments have shown that incorporation in the soil reduced the effectiveness of the materials.

In the experiments conducted, ferric sulfate and themodified iron sulfide (Fe_nS_{n+1}) have given the best yield responses. Rates of 125 pounds actual iron from either material have been sufficient to effect good yields. Except on soils with an exceptionally high exchangeable sodium percentage, 250 pounds of material per acre are not necessary. In the field experiments conducted ferrous iron at the 125 pounds per acre actual iron rate has not performed as well as other ferric materials.

A field experiment was also conducted to determine whether ferric sulfate could be topdressed on planted rice already showing the chlorosis typical of the "alkali disease" to effect correction of the problem. Ferric sulfate was broadcast into the water beginning 2 days after the chlorosis was first observed (12 days after planting). Treatments with ferric sulfate at the rate of 250 pounds actual iron per acre were made 14, 20, 23, and 28 days after the rice was sown.

Plants demonstrating symptoms of chlorosis responded to ferric sulfate top dressing within 2 days after treatment. The treated plants regained their normal green color and resumed active growth. Observations of the early vegetative growth response indicated that the earlier the treatment after develment of the chlorosis, the better the growth. Yield of paddy rice, obtained at maturity was significantly improved where ferric sulfate treatments were made. The data obtained in this experiment indicate that time of treatment did not significantly influence yield.

1/ Department of Agronomy and Agricultural Extension Service, University of California.

ABSTRACTS ON CONTROL OF RICE INSECTS AND WEEDS

COMPATIBILITY OF INSECTICIDES WITH THE HERBICIDE PROPANIL AS SPRAY APPLICATIONS ON RICE

C. C. Bowling and H. R. Hudgins[1]

Spray applications of certain insecticides are recommended for control of the rice water weevil, Lissorhoptrus oryzophilus (Kuschel), and the fall armyworm, Laphygma frugiperda (J. E. Smith), on rice The herbicide propanil (3, 4-dichloropropanilide) is recommended for control of certain species of weeds and grasses in young rice. Occasionally a field of rice may need an application of both insecticide and herbicide at or near the same time. Experiments were started at the Rice-Pasture Research and Extenstion Center, Beaumont, Tex., in 1962 to determine the compatibility of spray applications of various insecticides with propanil for use on rice.

The insecticides aldrin, dieldrin, Hepthachlor, thiodan, and DDT applied alone and in combination with propanil did not significantly reduce yields in these tests. The mixture of Sevin and propanil (1 Naphthyl N-Methyl Carbamate) caused severe leafburn, stand reduction, and highly significant yield losses.

1/ Assistant entomologist and assistant agronomist, Rice-Pasture Research and Extension Center, Beaumont, Tex., respectively.

INTERACTION OF INSECTICIDES AND PROPANIL IN RICE [1]

John B. Baker and Travis R. Everett [2]

Coincidental applications of propanil and some insecticides have caused severe damage to rice. With increasing use of propanil for grass control in rice fields, information was needed on compatibility of this chemical and insecticides.

A split plot experiment was used to screen insecticides for interaction with propanil. The whole plots consisted of an aldrin-treated seed versus untreated seed; subplots were sprays or granular applications of chlorinated hydrocarbon, phosphate, or carbamate insecticides applied just prior to the first flood or at heading of the rice. Propanil was applied at the rate of 3 lbs. active per acre in 20 gallons of water just prior to the first flood. Insecticides used at that time were applied following the propanil treatment.

Plots treated with carbaryl at the rate of 1 lb. per acre or Isolan at the rate of 2 lbs. per acre were severely damaged when sprayed with propanil. Both carbaryl and Isolan are carbamate insecticides. The carbaryl was applied as a spray, while Isolan was applied as a granular formulation. Applications of dieldrin at 0.25, phorate at 2 lbs., DiSyston at 2 lbs., Toxaphene at 2 lbs., and Bidrin at 1 lb. per acre at the time of the first flood did not alter the selectivity of propanil.

None of the plots sprayed with insecticides at heading showed any interaction with propanil.

In a second experiment, carbaryl was applied to rice 7 or 3 days before the herbicide, on the same days as the herbicide, or 3 or 7 days after application of propanil. All plots showed some damage. Those treated with insecticide after application of propanil were injured less than those treated before. Injury increased as the interval between herbicide and insecticide application decreased.

1/ In cooperation with Rice Experiment Station, Crowley, La.

2/ Associate professor, Botany Department, Louisiana Agricultural Experiment Station, Baton Rouge, La. Research Entomologist, Entomology Research Division, ARS, USDA, Baton Rouge, La., respectively.

SELECTIVE BREEDING FOR ACTIVE VECTORS OF HOJA BLANCA VIRUS [1/]

Travis R. Everett,[2/] H. A. Lamey,[3/] Wm. B. Showers,[2/] and Rodney Hendrick[2/]

A normal population of Sogata orizicola Muir contains 7 to 15 percent active vectors of the hoja blanca virus. This low incidence of virus transmitting insects has hampered studies on transmission of hoja blanca.

Methods previously used for selecting active vectors required several weeks, and the insects were 20 to 26 days old before their potential for virus transmission was established. With an average adult life of only 24 to 30 days, little time was left for utilizing the insects in virus transmission studies.

Research on virus transmission could be facilitated if:

(1) a population of insects with higher incidence of active vectors was developed, and

(2) the period required for determination of positive transmission was decreased so that active vectors might be obtained earlier in their life.

When viruliferous insects were caged on 3 to 4-day-old rice plants with 1 to 2 leaves, hoja blanca symptoms developed as soon as 3 days after caging the insect on the plant. Most of the plants that developed symptoms could be identified by the seventh day.

Insects that were caged on the plants as second instar nymphs transmitted the hoja blanca virus as effectively as fifth instars or adults. When third instar nymphs were placed on 3- to 4-day-old plants, active vectors were identified while the insects were still nymphs. With fourth and fifth instars the insects were young adults when the test was completed. In both cases, the transmitting insects could be mated to other transmitting insects with little or no loss in the number of eggs laid by the females.

Selective breeding was begun with a colony originally obtained in Louisiana in 1959, and maintained since that time in a screened greenhouse. Approximately 5 percent of the insects in this colony were capable of transmitting hoja blanca virus. Vector matings through successive generations--approximately 100 matings per generation--have resulted in a population with 80 to 100 percent active vectors.

Results of serial transfer of viruliferous S. orizicola on rice are presented in table 1. These data show that an active vector will not transmit hoja blanca virus every day and further that there is no regularity in the sequence of transmission.

Table 1. --Hoja blanca disease development on Bluebonnet 50 rice following daily transfer of active vectors.

Insect No.	Day[1/]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Males														
1	+	+	-	-	0	-	0	-						
2	+	+	+	0	0	+	+	-						
3	-	0	+	+	-	-	+	-	+	+	+	+	0	-
4	+	-	0	-	+	+	0	0	0	0	0	+		
5	+	+	+	-	-	-								
6	+	-	-	0	+	+	0	0	-	+	-	0	0	-
Females														
1	+	+	+	+	+									
2	+	+	+	+										
3	+	+	+	+										

1/ + Symptoms developed, - no symptoms, 0 no date.

1/ In cooperation with Lousiana Agricultural Experiment Station.

2/ Entomology Research Division, ARS, USDA, Baton Rouge, La.

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A second test, summarized in table 2, showed that caging insects for 3 days on test plants increased the probability of disease development in plants. Caging 1 insect for 3 days was more effective than caging 3 insects for 1 day.

Table 2.--Effect of caging periods, sex, and number of vectors on transmission of hoja blanca virus to Bluebonnet 50 rice by Sogata orizicola Muir.

Insects No.	Sex	Days of caging	Plants	Diseased
		Number	Number	Percent
1	M	1	60	55
3	M	1	16	68
1	M	3	18	89
1	F	1	27	93
1	F	2-3	14	93

USE OF ACTIVE VECTORS TO TRANSMIT THE HOJA BLANCA VIRUS [1/]

H. A. Lamey, W. B. Showers, and T. R. Everett[2/]

An improved method of testing rice plants for their reaction to hoja blanca virus was needed. To develop this method, preliminary tests were conducted using 3 standard rice varieties and active (virus-transmitting) vectors, produced, as described by Everett, Lamey, Showers, and Hendrick, by selective breeding of Sogata orizicola Muir. In a 3-year replicated field trial in Colombia; the varieties Bluebonnet 50, Arkrose, and Gulfrose were susceptibile, moderately resistant, and resistant, respectively. Tests revealed that confinement of 1 active male for 2 days resulted in high disease incidence in Bluebonnet 50, and low incidences in Arkrose or Gulfrose. Confinement of 1 active female for 1 day, resulted in high disease incidence in Bluebonnet 50, moderately high incidence in Arkrose, and low incidence in Gulfrose. Thus, the resistant reaction of Gulfrose could be distinguished from the susceptible reaction of Bluebonnet 50 by use of active insects of either sex. The reaction of Arkrose could be distinguished from that of Bluebonnet 50 only by use of active males, and from that of Gulfrose only by use of active females. The need for determining the reaction of parent varieties before testing progency of a cross was indicated.

Testing rice selections for reaction to the hoja blanca virus was accomplished by growing the rice in seeding flats and confining the vectors in 1-inch butyrate plastic cages for the required period. To maintain good growth during the winter months, natural lighting was supplemented with artificial lighting, and the plants irrigated with warm water. Maximum utilization of active vectors was accomplished by testing some rice selections with the newly emerged adults prior to mating. After mating, the males and any surplus females were used for further testing, and the remaining females used in the production of progency for the vector breeding program. Except for mating, each vector remained in the same cage at all times, a procedure which, by reducing handling, increased insect survival and reduced labor.

Ninety-six rice selections were tested with active vectors during a 6-week period in January to March 1964. These were all progenies from crosses of resistant by susceptible varieties. A few of these selections were the progenies of selections tested in Colombia in the summer of 1963. Agreement between the greenhouse and field tests were quite good. The only variance was in the progeny from segregating selections, which might be expected. All but 1 of 10 selections tested twice with active vectors showed consistent results between tests, even though very small samples (usually 10 to 16 plants) were used. Later, cataloguing was begun on a group of experimental varieties in the C. I. series. Since the reaction of these varieties was not known, all were tested first with active male vectors. Selections which gave a resistant reaction when inoculated with males were retested with females to distinguish the resistant from the moderately resistant.

In the tests conducted during January to May 1964, 372 Bluebonnet 50 plants were included as susceptible checks; 263, or 71 percent, developed hoja blanca symptoms. Disease incidence was about the same regardless of whether males or females were used. Duration of experiments varied from 14 to 31 days, and the mean was 23 days. In contrast, a previously used varietal screening technique, described in an earlier abstract, consisted in confining plants with a dense population containing only 10 percent active

1/ Cooperative investigations of the Crops and Entomology Research Divisions, Agricultural Research Service, U. S. Department of Agriculture, and the Louisiana Agricultural Experiment Station, Baton Rouge, La.

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vectors. Duration of such tests was 88 to 173 days, and the mean was 124 days. Using active vectors from the insect breeding program, 5 rice selections can now be tested in 1 seeding flat rather than 24 one-gallon crocks, as previously required. Moreover, soil requirements are one-sixth their former level, as is the time required to obtain results from a test.

HOSTS OF SOGATA ORIZICOLA MUIR AND REACTION OF DIFFERENT VARIETIES OF RICE TO THE HOJA BLANCA VIRUS

Gonzálo Granados[1] and Alejandro Ortega[2]

In the rice growing areas of Mexico, hoja blanca in rice is presently not a problem but its potential importance is well recognized.

In this paper, data are presented from

(1) experiments designed to determine the hosts of S. orizicola,

(2) transmission tests to obtain assurance that the disease symptoms observed on the rice plants were caused by the hoja blanca virus,

(3) tests performed to study the reaction of different rice varieties to the virus.

These experiments were conducted in the insectary at the Cotaxtla Center Research, State of Veracruz, during 1962 and 1963.

Six species of grasses, jaragua (Hyparrhenia ruffa), pangola (Digitaria decumbens), para (Panicum purpurascens), aleman (Echinochloa polystachia), privilegio (Panicum maximum), and buffel (Pennisetum ciliare), some grown from seed and others grown from vegetative parts, were studied as possible hosts of S. orizicola. Twenty-five insects (unsexed) were caged on each of the plants used, and kept until death. Data were also taken on the number of days the insects remained alive on the plant, preference for oviposition, eclosion, nymphal development, and adult emergence. Of the six species of grasses tested as possible hosts of S. orizicola, only privilegio and buffel were preferred for oviposition. In both grasses the eggs hatched, however, only on privilegio the nymphs reached the adult stage while on buffel the nymphs did not reach the second instar.

In the field a natural virus infection occurred in the varieties Jojutla, Bluebonnet 50, and Morado Criollo. Infected plants from these varieties were taken to the insectary as a source of virus infection for S. orizicola. These insects were used to infect 80 plants of Bluebonnet 50, originated from seed. These plants were divided into 4 groups of 20 plants each. Each plant was infested with 10 adults of S. orizicola which had been previously fed during 14 days on the infected plants. The first group of plants was infested when the plants were 14 days old, the next group at 28 days, the next at 42 days, and the last at 56 days. For each group of plants an additional group of 10 plants were used as a check. The results obtained showed that S. orizicola was able to transmit the virus from infected rice to healthy plants. Symptoms were observed in 45, 71, 60, and 15 percent of the plants, respectively.

Another test was conducted to estimate the reaction of some of the rice varieties most commonly grown in Mexico as well as the variety Gulfrose, three crosses of Bluebonnet 50 x Gulfrose, three crosses of Bluebonnet 50 x Dima, the susceptible variety Century Patna 231, and 12 varieties from Taiwan and Japan. The plants were infested with 4 insects each when they were about 20 days' old. The ability of the insects to transmit the virus had been increased previously by inbreeding to the point where 54 percent were capable of transmission. The insects were held on the plants from 2 to 8 days. After removing the cages and the insects, the

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plants were treated with Metasystox at 0.05 percent. A total of 15 plants of each variety was tested, 10 were infested, and 5 left as controls. In the Japanese type varieties 10 plants were used, 8 were infested, and 2 were left as checks. The results obtained indicated that of the varieties that are grown commercially in Mexico (table 1) 90 to 100 percent of the plants were infected, showing the typical symptoms of the disease. The variety Gulfrose and the cross Bluebonnet 50 x Gulfrose (B589A-21-35-3-4-2C-1C) were resistant, having less than 10 percent of the plants infected. Of the 12 Japanese type varieties tested Suiho was susceptible and Norin 37 and Norin 40 intermediate or tolerant. The remaining varieties were resistant (table 2).

Table 1.--Reaction of 22 varieties of rice to hoja blanca virus; using Sogata orizicola Muir as a vector, insectary conditions, Cotaxtla, Veracruz, 1963

Varieties	No. of plants inoculated	Plants age	Plants inoculated: Infected	Plants inoculated: None infected	Percent of Transmission
		Days	Number	Number	
Culiacan	10	20	10	0	100
Zacatepec	10	20	10	0	100
Antunez	10	20	10	0	100
Cubano Macuspana	10	25	10	0	100
Rexoro--Purple Leaf	10	20	10	0	100
Tempranillo de Colima	10	25	10	0	100
Bluebonnet 50	10	21	9	1	90
Jojutla Mejorado	10	22	9	1	90
Morado Criollo	10	20	9	1	90
Apatzingan	10	25	9	1	90
Tres Villas	10	25	9	1	90
Mochis	10	18	9	1	90
Jojutla de Colima	10	26	9	1	90
Century Patna 231	8	28	7	1	87
C_2-130-SZ-3-1	10	18	7	3	70
Bluebonnet 50-Gulfrose (B589A9-1-54-2C-2C)	20	20	14	6	70
Bluebonnet 50-Jojutla	10	23	5	5	50
Bluebonnet 50-Dima ($B585A_1$-46-3-1-1C-1C)	10	20	5	5	50
Bluebonnet 50-Dima ($B585A_1$-46-3-1-1C-2C)	10	18	3	7	30
Bluebonnet 50-Dima ($B585A_1$-15-3-2-5)	10	18	3	7	30
Gulfrose	20	20	2	18	10
Bluebonnet 50-Gulfrose (B585A-21-35-3-4-2C-1C)	10	18	0	10	0

Table 2.--Reaction of 12 varieties of rice "Japanese type" to hoja blanca using Sogata orizicola Muir as a vector. Insectary conditions. Cotaxla, Veracruz, 1963

Varieties	No. of plants inoculated	Plants age	Plants inoculated: Infected	Plants inoculated: None infected	Percent of Transmission
		Days	Number	Number	
Zuiho	71	32	43	28	60.5
Norin 37	53	20	11	42	20.7
Norin 40	62	20	7	55	11.3
Norin 22	52	26	4	48	7.6
Norin 39	62	20	3	59	4.8
Norin 18	61	26	2	59	3.2
Kimmazze	62	32	1	61	1.6
Norin 26	72	20	1	71	1.3
Taichu 65	72	26	1	71	1.3
Norin 13	87	26	1	86	1.1
Kinugasa Wase	147	32	0	147	0.0
Hatsu Shimo	75	32	0	75	0.0

THE RICE WATER WEEVIL IN CALIFORNIA

A. A. Grigarick[1/]

The rice water weevil, Lissorhoptrus oryzophilus (Kuschel), a common pest of rice in the Southern States, was unknown in California before 1959. An extensive survey by the California Department of Agriculture in the the summer of that year showed it to be limited to a 400 square mile area in the middle of the Sacramento Valley. Each succesive year its distribution has been extended until it is now found in all the major rice growing counties of the valley. Males of this species are common in other States but unknown in California which further indicates an accidental introduction of this weevil prior to 1959, possibly by a single parthenogenetic female.

Light-trap collections have shown peak flights of overwintering weevils in early April in 1962 and mid-May in 1963. The weevils from these spring flights can be found on weeds associated with the irrigation laterals or the levees of flooded rice fields. They readily move over to the rice when it emerges from the water, feed on the leaves, and oviposit in the submerged leaf sheath above the crown and in the roots. The larvae mine the leaf sheath for a short time and then move externally to the roots. This generation emerges from pupae on rice roots in mid-July and starts a second generation on rice in September.

The economic significance of this insect's presence on rice in California was of understandable concern to the industry. Cage studies with controlled populations of adults on continuously flooded rice showed a reduction in root length, plant height, number of tillers, and grain yield. At the ratio of one weevil per four plants a 7 percent reduction in grain yield was recorded while at a one to one ratio the reduction of grain was 31 percent. A field survey of adults rarely showed the number of weevils to equal the number of rice plants except in certain well-defined areas of the field.

To determine the distribution pattern of the weevils, a bimonthly survey of the adult feeding scars on rice and a biseasonal larval count were made in two rectangular rice fields at Biggs. The samples were taken at three different distances from the margins and from the four sides of each field. The results presented in table 1 show a strong preference of the weevils for the rice on the margins of the field.

A preference for shallow vs. deep water by the weevils has also been determined by recording the adult feeding activity and the presence of larvae on the roots (table 2). Fields with rice being grown at approximately 2, 4, and 6 inches of water were used for the study. It may be that the pattern of field margin distribution of weevils and the preference for rice grown in shallow water are the result of availability of suitable vegetation at the time of peak flights. These trends may not be as evident if the area-wide population of weevils were greater.

At the present time control recommendations are not being made for the rice water weevil in California but field tests show aldrin soil or seed treatments to be effective methods under our present rice cultural practices.

1/ Assistant professor of entomology, University of California, Davis.

Table 1--Distribution of rice water weevil in relation to field margin

Date	Percent of rice leaves with adult feeding scars		
	1 yd.	25 yd.	50 yd.
June 11	38	0	2
25	30	8	0
July 10	15	5	3
23	45	15	12
Aug. 6	90	25	30
20	95	29	27
	No. of larvae per plant		
July 12	1.37	0.05	0.00
Aug. 27	1.32	0.08	0.00

Table 2--Adult and larval rice water weevil feeding activity on rice grown at three water depths

Water depth (In.)	Percent plants with adult feeding scars	Larvae per plant
0 - 2	39	0.75
2 - 4	11	0.08
4 - 6	5	0.03

THE RICE WATER WEEVIL IN LOUISIANA [1]

Travis R. Everett[2]

The rice water weevil in Louisiana has been considered as Lissorphoptrus oryzophilus Kuschel. In 1963 an infestation of "root maggots" was found in Acadia parish that was composed of both L. oryzophilus Kuschel and L. simplex (Say). There have been no additional records for the latter weevil in other areas to date, although it has been found subsequently in Acadia parish. Males and females of both species have been collected.

Water weevils overwinter as adults, principally in plant litter and clumps of grass around rice fields. Samples of grass clumps and plant materials collected around a rice field in mid-winter yielded averages of 36 weevils per clump of Sporobolus sp., 31 per clump of Paspalum sp., 46 per clump of Andropogon sp., 4 from rice hay in the field, and 3 from mixed grasses and foliage around the field. One large clump of Paspalum sp. had a total of 143 adult water weevils. Close examination of the grass clumps showed that the weevils were situated about 1" above the soil, between the closely packed stems and sheaths of the grass. There appears to be a relationship between size and density of clump and the number of weevils found.

Weevils leave hibernation quarters and move into rice fields about the middle of April. However, a few weevils have been found in grasses in mid-May. "Sticky traps" were used to detect weevil movement. Based on weekly catches from April through May, the greatest activity was found during the middle of May. There was no significant difference in the number of weevils captured on traps painted green, white, yellow, or blue.

Female weevils removed from grass clumps were not mated and no eggs were found. Sperm were present in the testes of the males. Soon after emergence from hibernation quarters, weevils were observed in copula and samples of female weevils collected in rice fields had sperm in the spermatheca and eggs were found in the oviducts. As many as 22 apparently mature eggs were found in the common oviduct.

During these studies it became necessary to sex large numbers of weevils. The following characters have been found useful:

(1) There is a midline concavity in the first and second ventral abdominal segments of the male; convex in the female.

(2) Posterior edge of the pygidium of the female with a notch; straight in the male.

(3) Fifth ventral abdominal segment of male with a raised anterior half that is straight across the posterior edge; in the female the raised portion occupies more than one-half the segment and is curved posteriorly.

Aldrin seed treatment at a rate of 1/4 lb. toxicant per 100 lbs. of seed is recommended for "root maggot" control. Average yield increases of about 300 lbs. have resulted from water weevil control in Louisiana. Individual fields have shown field increases of treated portions of more than 1,000 lbs. over untreated areas.

Initial tests to determine the LD_{50} of Aldrin for rice water weevils indicated a potential resistance problem with use of aldrin. Weevils collected in Mississippi were from 50 to 350 times more resistant than those collected in Louisiana. The LD_{50}

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for weevils collected at Crowley was 0.11 micrograms at 72 hours and 0.04 micrograms at 96 hours.

In a field experiment to evaluate additional insecticides for water weevil control, diazinon at 1/2 lb. and CoRal at 1/8 lb. per 100 lbs. of seed, gave control equal to that obtained with aldrin. Both of these materials are being more thoroughly evaluated as possible insecticides for water rice weevil control.

CONTROL OF THE RICE STEM BORER BY USE OF CONTACT AND SYSTEMIC INSECTICIDES

M. D. Pathak and Elymar V. Vea [1/]

Several species of rice stem borers are pests of major significance in various parts of Asia. Of these, Chilo suppressalis Walker and Tryporyza incertulas Walker are most extensively distributed. The former constitutes approximately 90 percent of the stem borer population at the International Rice Research Institute. Most of the information presented here relates to Chilo suppressalis. Under local conditions all stages of development of the insect can be observed at any given time, and generations in overlapping cycles. Insecticidal treatments, therefore, cannot be timed to meet peak periods of moth emergence or of larval hatching. Instead, it becomes essential to protect the plants against stem borer infestation throughout their period of growth. This requires repeated insecticidal treatments, the number of which is greatly increased during the rainy season when frequent rains wash off the insecticide residues.

In trials during two dry seasons and one wet season in 1963 and 1964, 14 different insecticides were tested under field conditions for effectiveness in control of the stem borer. Each insecticidal treatment was replicated 4 times. These materials were applied as foliar sprays at 10-day intervals starting 2 weeks after transplanting and continuing till maturity of the crop. Five of the insecticides gave highly significant reductions in stem borer infestation, and the plots treated with these materials yielded about twice as much as the untreated controls. These treatments are too frequent and costly to be used by the farmers. Another simultaneous experiment was conducted to determine in what stages the plants are most susceptible to stem borer damage and to identify means to control the insect at those particular stages. The results indicated that rice plants can compensate for early stem borer damage if they are protected from further infestation during the period from 50 days after transplanting until harvest. If protection was not provided during this critical period, a sharp decline in yield resulted.

Although repeated foliar applications of contact insecticides resulted in a significant reduction in borer infestation, none of the compounds killed larvae already inside the plants. Because of the short residual effect of the insecticides used, long lasting protection was not realized and the infestations continued in all plots. Several systematic insecticides, as well as γ-BHC [2/], were tested for their efficiency in killing larvae present within the plants. These compounds were applied directly into the irrigation water. A number of these gave satisfactory results, but γ-BHC was selected for further study because of its low mammalian toxicity and its long residual effects. In a series of tests using different dosages of γ-BHC, it was found that when mixed with irrigation water at the rate of 3 kg./ha. of active ingredient, it killed the larvae present within the plants and was effective for about 1 month after treatment. A wide variety of other insect pests in the rice fields also are killed when the insecticide is applied at this rate.

Thus, considering 50 days after transplanting as the proper stage for the first γ-BHC treatment, only two applications are needed for a crop having a growth period of 4 months from transplanting to harvest. Determination of the residue of the insecticide in the straw and grain now are being conducted.

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2/ -BHC (gamma benzene hexachloride), also known as "Lindane."

RICE STEM BORERS AND THEIR PARASITES IN THE AMAMI ISLANDS OF JAPAN

Toshiyuki Nishida[1]

The two main stem borers of rice observed on the Amami chain of islands situated bewteen Okinawa and Kyushu Island, Japan, were *Chilo suppressalis* (Walker) and *Schoenobious incertulus* (Walker). A marked difference in the distributional patterns between *C. suppressalis* and *S. incertulus* was observed; the former being predominant on Okinoerabu and Yoron Islands and the latter, on Amami Island. This difference in the distributional pattern appeared to be associated with topographic features. Two braconid parasites of these two species of borers were found, *Bracon chinensis* Szépligeti and *B. onukii* Watanabe. The damage to rice by the borers was high in areas where these parasites were scarce, and low in areas where the parasites were abundant.

1/ University of Hawaii.

LABORATORY EVALUATION OF INSECTICIDES FOR CONTROL OF THE RICE DELPHACID[1]

Wm. B. Showers[2], Mitsuo Yoshemeki[3], and Travis R. Everett[2]

The rice delphacid, Sogata orizicola Muir, is a pest of rice in Central and South America. Infestations of this insect reduce the yield of rice and young plants may be killed. Hoja blanca virus is transmitted by this insect.

Sporadic infestations of the rice delphacid have been detected in Florida, Louisiana, and Mississippi since 1957. A colony of the insect has been maintained in a screened greenhouse at Baton Rouge, La., since 1959 for use in research on the biology and control of hoja blanca and its vector.

An important part of this research work at the Rice Insects Investigations Laboratory has been the evaluation of insecticides for control of S. orizicola. Candidate compounds were tested as seed treatments, sprays, granules applied to the soil, and/or solutions in the flood water. Insects were caged on the treated plants at intervals following insecticide applications. Data were collected on insect mortality at 6, 24, 48, and 72 hours after caging. Viruliferous insects were used in some tests to see if the insects were killed before hoja blanca virus could be transmitted to the plant.

Bayer 25141, Bayer 39007, Bidrin, dimetilan, Di Syston, Isolan, and menazon were applied to Nato rice seed at the rates indicated in table 1. All compounds except Bayer 39007 and menazon were rejected as seed treatments due to phytotoxicity. Bayer 39007 has given excellent control of S. orizicola up to 25 days following planting. Viruliferous insects caged on these plants were killed before hoja blanca virus was transmitted. Menazon was less effective than Bayer 39007 as a seed treatment.

Table 1--Control of S. orizicola with insecticides applied to rice seed

Insecticide	Dosage Lbs./100 lbs. of seed	Days after treatment: 10 days	18 days	25 days
		% Mortality[1]		
Bayer 39007	1.0	100	90	63
Do.	2.0	100	68	78
Bidrin	1.0	100	35	15
Menazon	1.0	84	20	15
Do.	2.8	76	72	18
Check		0	0	0

1/ Within 24 hours after caging insects on rice plants. Corrected with Abbots formula for mortality in the check.

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Granular formulations of the following insecticides were applied to the soil: Bayer 25141, dimetilan, Di Syston, Isolan, and phorate. Results of the tests with granules are given in table 2. Phorate, Di Syston, and Isolan applied at the rate of 2 lbs. toxicant per acre gave good control up to 33 days after treatment. None of the materials applied at the rate of 1 lb. per acre gave adequate control.

Table 2--Control of S. orizicola with granular formulations of insecticides applied to soil

Experiment	Insecticide	Dosage rate lbs./acre	Days after treatment					
			14	21	29	39	46	56
			Percent Mortality 1/					
I	dimetilan	2.0	67	67	58	31	11	13
	Isolan	2.0	100	100	93	57	17	11
	phorate	2.0	91	86	78	75	33	11
	Check	---	0	0	0	0	0	0
			Days after treatment					
			11	19	27	33		
II	Bayer 25141	1.0	17	0	17	52		
	dimetilan	.5	39	0	57	9		
		1.0	13	50	61	13		
	Di Syston	2.0	96	100	87	65		
	Isolan	.5	4	0	30	18		
		1.0	65	0	22	30		
	phorate	1.0	48	31	13	30		
	Check		0	0	0	0		

1/ Within 24 hours after caging insects on the plants. Corrected with Abbots formula for mortality in the check.

Insects were caged on individual leaves to determine the location of systemic insecticides within a rice plant. Isolan was generally distributed throughout the rice plant; both old and young leaves contained sufficient insecticide to produce significant mortality. Phorate appeared to move into the newer growth in greater concentration. The older leaves of plants treated with dimetilan contained more toxicant.

Sprays of Bidrin, carbaryl, a DDT-malathion mixture, diazinon, menazon, phosphamidon, dimethoate, dimetilan, and Isolan were applied to rice plants at the rates indicated in table 3. The latter 3 materials were phytotoxic. Bidrin, carbaryl, and phosphamidon applied at the rate of 1 lb/acre gave excellent control of insects introduced 1 day after treatment. Bidrin continued to give control as long as 7 days after treatment. All other materials tested gave less than 50 percent control of S. orizicola.

Solutions of insecticides were used to water young rice plants. This treatment was intended to simulate the addition of insecticides to the flush water in a rice field. Rates of application were equivalent to 46 p.p.m. of Bidrin, GS 13005, dimethoate, and Isolan and 12 p.p.m. Isolan in about 0.2 acre inches of water. The results of these treatments are presented in table 4.

Bidrin, dimethoate, and Isolan gave at least 50 percent control within 24 hours after caging and up to 15 days following treatment. The control with Isolan was good up to 22 days after application of the flush.

Table 3--Control of S. orizicola with insecticides applied as sprays to rice plants

Insecticide	Dosage lbs./acre	Days after treatment 1	7
		Percent Mortality 1/	
Bidrin	0.25	20	-
	.5	63	-
	1.0	100	68
Carbaryl	1.0	89	-
DDT-malathion	1.0-0.5	16	-
Diazinon	.5	15	-
Menazon	1.0	11	-
Phosphamidon	.5	71	-
	1.0	90	16
Check	-	0	0

1/ Within 24 hours after caging insects on the plants. Corrected with Abbots formula for mortality in the check.

Table 4--Control of S. orizicola with insecticides applied in the flush water

Insecticide	Dosage p.p.m. in water 1/	Days after flush treatment 1	2	8	9	15	16	21	22
		Percent mortality 2/							
Bidrin	46	100	100	85	96	81	92	16	23
GS-13005	46	53	-	15	-	39	-	0	-
dimethoate	46	89	-	60	-	50	-	15	-
Isolan	46	100	-	100	-	83	-	45	-
	12	-	32	-	88	-	88	-	23
Check	-	0	0	0	0	0	0	0	0

1/ 46 p.p.m. gave equivalent of 2 lbs. per acre.

2/ Within 24 hours after caging insects on the plants. Corrected with Abbots formula for mortality in check.

RESEARCH ON CHEMICAL CONTROL OF INSECT VECTOR OF HOJA BLANCA IN RICE

Alfredo Saldarriaga[1/]

The effectiveness of several insecticides against Sogata orizicola Muir, the insect vector of hoja blanca, was compared for the past 5 years. Both resistant and susceptible varieties of rice were used in the tests. Insecticidal sprays and dusts were applied 3 or 4 times during the season depending on the insect population: after germination, before tillering, after tillering, and before panicle formation. A randomized complete block design with 4 replications was used in the experiments. Each plot contained 5 to 7 rows, spaced 30 centimeters apart. The effectiveness of insecticidal treatments was evaluated by a comparison of insects collected in 10 sweeps of an insect net, the percentage of plants showing hoja blanca, and yields of rice in treated and untreated plots.

Results of 10 field experiments carried our at Palmira, Colombia, from 1958 to 1963 are presented.

In general, the results of sweep net collections and estimates of percentage of hoja blanca were not satisfactory criteria for evaluation of the action of the insecticides. Data on yields of rice showed significant difference among the insecticide treatments.

In three preliminary tests, sprays of DDT 50 percent W. P., parathion 50 percent E. C., endrin 19.5 percent E. C., demeton 50 percentE. C., applied after germination only, toxaphene 20 percent dust at rates of 1.5, 0.25, 0.25, 1.0, and 30 lbs./acre, respectively, and phorate 50 percent E. C. as a seed treatment at the rate of 2 lbs./ton of seed were applied to a susceptible variety of rice. Only the endrin and phorate treatments increased yields significantly, however, when the same insecticides at the same rates of application were used in plots planted with a resistant variety, all the treatments showed significantly greater yields than the untreated plots.

The second series of experiments was made with sprays of endrin 19.5 percent E. C., demeton 50 percent E. C., toxaphene 50 percent E. C., Telodrin 15 percent E. C., mixture of toxaphene-DDT 40-20 percent E. C., metosystox 25 percent E. C. and Thimet phorate 10 G. applied in the row at planting time, at the rates of 0.25, 0.50, 2.00, 1.0 to 0.5, 0.25, and 2.00 lbs. per acre, respectively. It appeared from the data secured and from frequent observations of fields treated in all stages of growth, that with any of the insecticides above named, it is possible to gain considerable benefit in yield. In these tests, yield increases were measured in both susceptible and resistant varieties. Data from the third series of experiments initiated in 1963 showed that the insecticides Thiodan, 35 percent E. C., Ekatin 20 percent E. C. and Sevin 50 percent W. P. applied at rates of 1.5, 0.25, and 2.0 lbs./acre, respectively, increased the yield of rice. Additional tests are needed to further evaluate these materials.

Although there were no significant differences among the insecticides used in the tests on susceptible varieties, the following facts should be pointed out. It was found that phorate, as both a soil and seed treatment, was phytotoxic. However, the plants did recover at a later date.

The most promising materials tested were endrin, demeton, the mixture of toxaphene-DDT, Telodrin, metasystox, and Sevin. Although satisfactory reduction in Sogata population were obtained, no difference in the percentage of hoja blanca was

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noted between treated and untreated plots. When populations of insects were high, as many as five applications of insecticides were made; in most tests only three applications were needed for insect control. Early applications of insecticides reduced seedling mortality due to hoja blanca disease.

Observations on different planting dates indicated a relationship between time of seeding and the percentage of hoja blanca in the experimental plots. Further investigations are needed to establish this point.

CONTROL OF THE RICE LEAF MINER

W. H. Lange[1]

California rice suffered an unprecedented attack of the rice leaf miner, Hydrellia griseola (Fallen), during May and June 1963. This was apparently the most severe attack since 1922 when De Ong reported damage. In 1953 approximately 165,000 of the 412,000 acres in California were treated with insecticides, largely dieldrin, which was disbursed by airplanes within a period of about 2 weeks. Losses were estimated at from 10 to 20 percent of the crop or about 16 million dollars. Losses to individual fields ranged from no observable damage to complete losses. All fields under observation recovered partly or completely following the application of dieldrin at 4 to 8 ounces of actual material per acre applied in 10 gallons of water. Following the first application of dieldrin on May 28, 1953, extensive bird and fish kills were reported by June 4 and restrictions were placed upon the use of dieldrin unless by written application of the grower.

Since 1953 about 10 to 20 thousand acres have been treated annually for leaf miner control. Damage in most years is limited to slow growing rice occurring in the borrow pits in deep water areas, and in ecological situations where deep water persists in May and June. During the period following 1953 until the present time, field experiments on chemical control were possible in 1954, 1955, 1958, 1962, and 1963. The limiting factor in most instances was the ability to locate suitable infestations. Rather than attempt to summarize all of the tests run during this period, I will present a tabulation (Table I), which gives the rate used per acre and the percent control of larvae inside the mines in comparison with untreated checks.

In recent work, parathion at rather low rates, 1.6 ounces per acre, has been effective in killing larvae inside the mines and does not have the disadvantage of building of residues in the soil that might later get into biological systems.

In connection with residue work we find that with most materials, most residues disappear within 48 hours following application. Dieldrin apparently settles into the mud and remains for more extensive periods of time. More work is needed on the fate of chemicals in rice fields and also the means by which materials leave rice fields following their entrance into the mud.

Table 1--Materials tested for leaf miner control

Material	Rate actual toxicant per acre	Control of larvae inside mines
Dieldrin	4	91-100
Diazinon	4-24	66-100
Phorate (Thimet)	4	76
Aldrin	2-4	83-89
Isodrin	2-4	68-72
Endrin	2-4	74-87
Heptachlor	2-4	89-100
Chlordane	2-4	63-78
Malathion	4-24	69-95
Lindane	16	54
Demeton	4	0
Guthion	4	71
Phosdrin	4	20
Bayer 25198	4	100
Bayer 25141	4-8	39-100
1189	4	3
12880	4	6
18706	4	10
Korlan	4	76
Dicapthon	4	37
CP10502	4	11
39007	8-16	30-53
Pyramat	8-16	65
DDT	16	87
Dylox	16	24
DDVP	8	41-50
7438	8	14-43
Sevin	24	42
Bidrin	8	33-55
Parathion	1.6-8	100

1/ University of California, Davis.

In addition to chemical control, water management has also entered into the control of the rice leaf miner. Deep water and prolonged growing conditions often increase damage and for this reason lowering the water gradually has often been helpful in reducing damage from the miner. It is also found that proper water levels during the growing season greatly decreases damage from this insect. With the advent of more efficient weed control materials it is now possible to grow California rice with much less water and thus avoid the possibility of extensive leaf miner damage.

CRAWFISH PRODUCTION IN RICE PADDIES TREATED WITH ALDRIN, CARBARYL, AND METHYL PARATHION [1/]

Rodney D. Hendrick and T. R. Everett [2/]

Crawfish production in rice fields is common practice in Southwest Louisiana. No information was available on the effect of insect control measures on crawfish production. In the spring of 1963, a field experiment was initiated to investigate crawfish production in paddies treated with insecticides. Experimental plots were located at the Rice Experiment Station, Crowley, La.

The experiment consisted of four replications of six treatments. The treatments were as follows:

1. Aldrin applied as a seed treatment at 0. 25 lb. /100 lbs. seed.
2. Methyl parathion applied as a spray at the time of heading at the rate of 0. 25 lb. per acre.
3. Carbaryl applied as a spray at the time of heading at the rate of 0. 8 lb. /acre.
4. Aldrin applied as a seed treatment at 0. 25 lb. /100 lbs. seed and methyl parathion as a spray at the time of heading at the rate of 0. 25 lb. /acre.
5. Aldrin applied as a seed treatment at 0. 25 lb. /100 lbs. seed and carbaryl as a spray at the time of heading at the rate of 0. 8 lb. /acre.
6. Untreated check.

Each plot was 40 x 40 feet surrounded by an earth levee. An 18-inch-high fence of 12 mil. polyethylene plastic was placed on top of the levee to prevent migration of crawfish. In October the polyethylene fence was replaced with one of 14-mesh aluminum screen.

Rice was drill planted at the rate of 100 labs. /acre. The plots were stocked with 50 pairs of crawfish per plot. This stocking was necessary as no crawfish are found in the field in the Rice Station. Soil samples taken prior to planting showed residues of 0. 25 to 1. 07 p. p. m. of aldrin and dieldrin remaining from an application of 5 lbs. of dieldrin per acre in 1958. Prior to this treatment, crawfish were found on the Experiment Station property.

Periodic checks were made on the crawfish populations through the summer, fall, and winter. In February crawfish of marketable size (14. 5 gms. or larger) were present in the plots. A systematic harvest of crawfish was begun on February 11 and continued at biweekly intervals until April 25 when all plots were drained and harvesting was completed. A sample of crawfish was removed from the collections of February, March, and April and frozen for residue analysis.

No mortality was observed in the brood crawfish placed in the plots. The brood crawfish increased 4 to 7 times in weight in all plots by mid-August.

All crawfish trapped prior to February 11 were weighed, measured, and returned to the plot. Beginning with the February 11 collection residue samples and harvestable sized crawfish were removed. The numbers and weights of the crawfish harvested on the 5 sampling dates are presented in table 1. Data on yield in numbers and in pounds have

1/ In cooperation with the Rice Experiment Station, Crowley, La., and Louisiana State University Cooperative Wildlife Unit, Baton Rouge, La.

2/ Graduate research assistant, Entomology Department, La. Agr. Expt. Sta., and Research Entomologist, Entomology Research Division, ARS, USDA.

been subjected to analysis of variance. The F value in both yield numbers and weights indicated a significant difference in yields of the treatments. The comparison of aldrin treated plots vs. non-aldrin treated plots showed no significant differences. Comparison of methyl parathion and carbaryl vs. the check was significant in weight but not in numbers. Aldrin alone was significantly different from aldrin and methyl parathion and carbaryl and aldrin in both weight and numbers harvested. Residue in crawfish from aldrin treated plots and non-treated plots are essentially the same. These data are presented in table 2.

Aldrin, methyl parathion, and carbaryl at the rates tested do not decrease the production of crawfish in rice fields. The combination of aldrin seed treatment and methyl parathion as a spray are the insect control measures most compatible with crawfish production. Carbaryl applied as a spray to fields planted with aldrin-treated seed may cause some decrease in crawfish yields.

Table 1--Average weight of crawfish harvested

Treatment	No. harvested	Total wt. grams (Grams)	Average wt. (Grams)	Mean Production of Crawfish/Acre Treatment Yield in lbs./acre
1	1309	31,058.3	23.73	557
2	1039	26,397.5	25.41	252
3	948	23,889.3	25.20	228
4	905	20,860.7	23.05	199
5	499	13,777.2	27.61	132
6	786	19,104.0	24.31	173

Table 2--Analyses of aldrin and dieldrin in crawfish produced on treated and untreated plots, Rice Experiment Station, Crowley, La., 1964. (Analysis by Miss Frances Bonner and Associates, Feed and Fertilizer Laboratory Louisiana State University)

	Aldrin (p. p. m.)	Dieldrin (p. p. m.)
Treatment 1 (Aldrin on seed at 0. 25 lb. / 100)		
Replicate I	2. 1	1. 2
Replicate II	2. 1	. 4
Replicate III	1. 6	. 5
Replicate IV	3. 9	. 6
Average	2. 4	. 7
Treatment 6 (Check, no treatment)		
Replicate I	22. 9	2. 7
Replicate II	1/	. 6
Replicate III	1/	. 4
Replicate IV	1/	. 4
Average		1. 0

1/ Not detected at 0. 4 parts per billion HHDN.

ABSTRACTS ON PROCESSING, COMPOSITION, AND NUTRITION

THE EFFECT OF LENGTH OF STORAGE ON THE FATTY ACID COMPOSITION OF RICE LIPIDS

Ten-ching Lu and Virginia R. Williams[1]

Milled rice obtained from freshly harvested grain is well known to be less suitable for both culinary and processing utilization than rice that has been stored or aged prior to use. Although rice investigators have advanced several theories to explain this difference in quality resulting from aging, the basic nature of the phenomenon is still not understood.

Preliminary results obtained in our laboratory with a number of domestic varieties suggested that there might be changes in fatty acid composition during aging. Accordingly, we have made an intensive study of one uniform sample of rice to determine whether significant changes did occur. Freshly harvested rice of the Belle Patna variety was obtained from the Rice Experiment Station, Crowley, La., in July 1963. Biweekly analyses of the fatty acid composition of the extractible lipids were carried out over a 6-month period.

The rough rice was stored in the laboratory in a closed container maintained at constant temperature (25° C.), and samples were withdrawn every 2 weeks for milling and an analysis. The milled rice was ground to 40 mesh and exhaustively extracted with chloroform-methanol (2:1, v/v) in a Soxhet apparatus. Silicic acid chromatography of the lipids yielded four fractions: cholesteryl esters; triglycerides; free chlolesterol, free fatty acids and mono- and diglycerides; and phospholipids. With the exception of the cholesteryl esters, all fractions were methylated by transesterification, using methanol and 2, 2-dimethoxypropane. The methyl esters were gas chromatographed on 20 percent diethylene glycol succinate polyester containing 20 percent phosphoric acid, with 80 to 100 mesh Chromport as solid support. Quantitation was achieved by the use of standard methyl esters; peak area was measured with a planimeter.

A significant increase in oleic acid and a decrease in linoleic acid was found in the phospholipid fraction over the 24-week experimental period. No other significant correlations could be found between the remaining fatty acid components and storage time.

The linoleic acid to oleic acid ratios were larger than unity, in agreement with our previous results on the lipids of domestic rice varieties. These findings, however, are at variance with a recent report on the fatty acid composition of oriental rice varieties. Although different methods of extraction and methylation have been used by the two laboratories, the marked compositional differences may be a reflection of genetic variation in the rices rather than the result of different analytical techniques.

The three major fatty acid components of rice lipids were found to be palmitic, oleic and linoleic acids, in agreement with our previous work and with recently published analysis. The five minor constituents were myristic, palmitoleic, stearic, linolenic and arachidic acids. The data also indicated that a monoethylenic C_{14} and a diethylenic C_{16} component were present.

1/ Graduate student and professor of Biochemistry, respectively, Louisiana State University, Baton Rouge, La. This research was supported by a grant from General Foods Corporation.

CHANGES IN THE COMPOSITION OF RICE ASSOCIATED WITH KERNEL INFECTION BY HELMINTHOSPORIUM ORYZAE

Harry W. Schroeder [1/]

Helminthosporium oryzae Breda de Haan commonly infects the panicles and kernels of rice in the Southern Rice Area. Kernel infections may approach 100 percent in some fields by harvest. The pathogen is a cause of kernel discoloration in white rice, "peck" in parboiled rice, and kernel breakage during milling. Recent investigations in this laboratory have indicated that yields may be reduced as a result of the metabolism of kernel constituents by the fungus; moreover, such losses may continue after harvest, until the rice is dried to a moisture content low enough to inhibit the continued growth of the pathogen. The present study delineates some of the changes in kernel constituents associated with growth of H. oryzae.

H. oryzae was grown in submerged cultures on a medium consisting of 1 gram ground brown rice (0.877 g. dry weight) in 100 cc. distilled water. Replicate cultures were harvested at intervals over a period of 25 days. The rate of growth of the fungus, measured by the dry weight of the mycelium, was most rapid during the first 7 days and mycelial weights continued to increase at a reduced rate through 22 days. A high rate of mycelial growth was accompanied by rapid loss of dry matter in the medium with a corresponding increasing net loss of dry matter; i.e., after 9 days, the mycelium, medium, and net loss of dry matter accounted for 36, 27, and 37 percent, respectively, of the rice solids originally in the medium.

The reducing power of the medium increased rapidly to a maximum of 2.0 mg. glucose equivalents per ml. of medium in 7 days from an initial concentration of 0.05mg/ml. After 7 days, the reducing power decreased at an accelerated rate. Since the rice solids were liquified after 3 days' growth (visual determination), it is assumed that the higher molecular weight carbohydrates were exhausted in the medium after 7 days. The extra-cellular amylase activity followed a similar pattern, reaching a maximum of 0.20 mg. glucose equivalents/ml./hr. at 40 C. in 7 days, and 0.00 after 11 days.

Changes in the constituents of the medium were accompanied by changes in its pH. From an initial pH of 6.30, a minimum of 4.10 was reached in 11 days. Thereafter, the trend reversed, reaching a pH of 9.80 after 22 days.

Although the effects of H. oryzae infection of rice cannot be directly interpreted on the basis of this study, the results are indicative of the ability of the fungus to develop an extra-cellular enzyme system capable of rapid degradation of rice constituents, especially the long-chain carbohydrates. That changes in the carbohydrates of rice result from H. oryzae infection was shown by paper chromatography of extracts of infected and non-infected rice. Reducing sugars were not detected in heavily infected rice; however, after parboiling comparable samples, glucose was detected. These data suggest that the fungus is metabolizing the sugars as rapidly as they become available in heavily infested rice. Further, the extra-cellular enzymes are selectively affected by the parboiling process or more complex extra-cellular molecules are degraded by the high temperatures, leaving the glucose moiety free.

The free amino acids of extracts of infected and non-infected rice were also examined by paper chromatography. Both the number of amino acids detected and their concentrations were affected by heavy infections of H. oryzae. In infected rice 20 amino

1/ Research plant pathologist, Market Quality Research Division, Agricultural Research Service, U.S. Department of Agriculture, College Station, Tex., in cooperation with the Texas Agricultural Experiment Station.

acids were detected compared to 13 in non-infected samples. The concentrations of all amino acids increased as a result of infection but glutamic acid, histidine, arginine, proline, γ-amino-n-butyric acid, asparagine, and glutamine showed the most marked increase. After parboiling infected samples, aspartic acid, valine, leucine (s), phenylalanine, tryptophan, lysine, and methionine increased in concentration; glutamic acid, histidine, proline and glutamine decreased. These results are similar to those reported in a manuscript prepared for publication at this laboratory reporting the effects of infection of rice by Fusarium chlamydosporium.

The complex extra-cellular enzyme systems developed by H. oryzae growing on rice kernels have not been adequately studied; however, it is apparent from the present investigation that the fungus is an organism that is well adapted for growth on rice. It is capable of causing marked changes in the constituents of the kernel and loss in yield, as well as kernel discoloration. Losses to the rice industry, caused by this widespread pathogen, may well exceed losses attributed to any other disease.

RICE COATING

Robert E. Ferrel[1/]

Current rice investigations at the Western Regional Research Laboratory include work on two related problems in coatings for rice--

(1) to develop new methods for producing sheen or gloss on milled rice and

(2) to produce a totally enriched rice with rinse resistance that eliminates or minimizes the yellow color contributed by riboflavin.

Traditional methods for producing the sheen on milled rice demanded in many markets utilize glucose and talc and are currently under question by the Food and Drug Administration because the siliceous talc cannot be assimilated by the body and in fact is rinsed off before the rice is consumed. Our efforts have centered on finding a substitute for talc that can be used in present processes and that can be utilized in body nutrition. Several classes of materials have been investigated for suitability as sheen producers based on their probable ready acceptance as food additives. These include

(1) closely related food materials such as fine-grind and air-classified cereal flours, starches, and modified starches,

(2) animal and vegetable fats, fatty acids, and modified fatty acids, and

(3) small-molecular-weight carbohydrates such as sugars and polyhydric alcohols.

Because diets high in cereal products frequently require calcium supplementation, calcium salts of both inorganic and organic acids were also investigated.

Subjective evaluation indicates that certain calcium salts of organic acids and some low molecular weight carbohydrates can be directly substituted for talc at about equal concentrations in presently used industrial processes to produce sheen equal to that presently obtained.

Still under investigation are means for objective measurements of the sheen produced and organoleptic evaluation of rice coated with the various talc replacements that produce acceptable sheen.

Of equal or greater significance to the rice industry is the total enrichment of milled rice. Riboflavin has always been included as a required nutrient in Federal Standards of Identity for enriched rice but has not been enforced because of problems associated with its intense yellow color. Pressure is developing, however, for enforcement of this requirement. Preliminary investigations leading to enrichment of all rice grains with all required nutrients in a rinse-resistant manner are underway. Techniques have been developed for uniformly applying the nutrients at the highest level in aqueous dispersion without excessive checking or cracking of the grains while keeping discoloration due to riboflavin to a barely perceptible level. Moderate, but as yet insufficient, rinse resistance has been impaired.

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PROTEIN DISTRIBUTION IN BROWN AND MILLED RICE

J. T. Hogan, F. L. Normand, and H. J. Deobald[1/]

Recent investigations by the Rice Investigations Group of the Southern Utilization Research and Development Division on the distribution of protein in the rice kernel have demonstrated a high concentration of protein in the outer layers of conventionally milled rice kernels. These findings confirm earlier observations made by a group of Spanish research workers at Valencia, Spain Revista de Agroquimica y Technologia de Alimentos, 3(1): 22-26 (1963) .

A method of milling brown rice or overmilling conventionally milled rice was developed which tangentially subjected the surface of the kernels to the action of a rapidly moving abrasive surface and permitted removal of the outermost layers with a minimum of breakage and an insignificant development of frictional heat. Optimal operating conditions allowed each individual rice kernel to be briefly and cyclically subjected to the abrasive action of the rapidly rotating knurled-surfaced disc.

Consecutive layers of whole brown rice of the Bluebonnet 50, Nato, and Caloro varieties and of a commercially milled rice (predominantly Bluebonnet 50) were successively removed, with very little breakage, by means of this specially constructed laboratory scale mill and collected as a finely divided flour.

The results confirmed the occurence of high protein-bearing layers on the outer surfaces of the endosperm of the three brown rices and the commercially milled sample. In the case of the brown Bluebonnet 50, for example, removal of seven consecutive weight fractions, each fraction averaging approximately 4 to 5 percent by weight of the original kernel, indicated that the protein content of each layer was higher than the average protein content of the original kernel, which analyzed 8. 8 percent protein. Protein content of fraction 1 through fraction 7, ranging from 21 percent for fraction 2 to about 10 percent for fraction 7, furnished evidence of the presence of high protein content material in the outermost portions of the Bluebonnet 50 kernel. This relationship was also generally true for the Nato and Caloro brown rice samples as well as the commercially milled rice. The commercially milled Bluebonnet 50 rice (8. 1 percent protein) contained an outer layer of material ranging from 19 percent at the surface to about 9 percent somewhat less than halfway toward the center in a total weight fraction representing about 35 percent of the original kernel's weight.

Organoleptic evaluation of the cooked residual rice after successive surface removal of selected fractions indicated that milled rice, which had approximately 7 percent additional surface removal of the kernel weight, exhibited greater whiteness, no difference in flavor or size after cooking, a decreased loss of solids during cooking, and compared favorably in cohesiveness with a control.

Preliminary investigation of the fine grinding and air-classification of the flour prepared from the outer 20 percent by weight of the peripheral areas of conventionally milled rice and containing 18. 5 to 18. 7 percent protein, conducted in cooperation with the Cereals Laboratory, WURDD, indicated a lack of any additional or unusual protein spread despite normal size distribution.

The technique employed in removing the layers, without impairment of the physical and cooking qualities of the residuals kernels, presents a method which may prove of interest and assistance in future studies of rice composition, quality, and histology concerned with the distribution of rice constituents, such as fat, protein, amino acids, vitamins, and minerals.

1/ Chemical engineer, chemist, and head, respectively, Rice and Sweetpotato Investigations, Food Crops Laboratory, Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, New Orleans, La.

A potential aspect is the practical availability of rice flour fractions containing from 15 to 20 percent protein, which represents separation of a higher protein material than has previously been obtained by conventional air-classification of whole rice flours.

The amino acid composition of the proteins and the vitamin content of these flours are presently being determined to establish the nutritional potential of these products for use or incorporation in U.S. baby foods, special dietary products, and for use in protein-deficient areas of the world, where rice is a main constituent of the diet and there is a need for rice products of higher protein content and nutritional value than is commonly found in the milled grain.

HIGH PROTEIN RICE FLOURS

D. F. Houston, A. Mohammad, T. Wasserman, and E. B. Kester[1/]

Nutritious high-protein flours potentially useful for infant and geriatric foods have been prepared from both normal and high-protein rices by two relatively simple processes using commercial types of machinery. One process consists of grinding the rice to an exceedingly fine flour and classifying it by particle size in a cyclone type air separator. The second process is an overmilling. Flour is scoured from consecutive layers of milled rice in a continuous-flow abrasive cone mill similar to a rice whitening cone. Results of the two processes are compared.

In the air classification process, protein accumulated in the fine-particle fractions. Protein concentration in the fraction with smallest particles reached about double the the original concentration and decreased with increasing particle size. Some 8 to 10 percent of flour produced had 75 percent higher protein than the original, and 75 to 80 percent had slightly less protein. Fat, ash, thiamine, riboflavin, and amylase activity were distributed in a manner similar to the protein and generally were concentrated to a slightly greater degree.

The overmilling process operated satisfactorily both on a batch and a semi-continuous basis. Flour from outermost layers of rice had about twice the protein content of the original kernels and was obtained in 10 to 15 percent yield. Subsequent layers yielded flour with decreasing protein contents. The residue consisted chiefly of whole kernels with slightly reduced protein content, together with some broken grains. Again fat, ash, thiamine, riboflavin, and amylase activity followed the trend of protein content. How, ever, proportional increases were larger than in the air-classification process, and reached 5 to 8 times their original concentrations.

Fine-grinding and air classification of the highest protein flour obtained by overmilling effected a further protein concentration. A 15. 5 percent protein flour obtained by overmilling a 9. 6 percent protein white rice yielded a 19. 9 percent protein finest particle fraction by air classification, and about one-fourth showed enhanced protein. Fat content was similarly fractionated. Fat removal did not improve the classification.

Comparison of the two processes indicate that overmilling is the more favorable one for rice. The yield of high-protein flour is comparable from the two processes, but concentration of other nutrients are greater by overmilling. Also, overmilling leaves the majority of material as a whole-grain rice of slightly reduced protein content suitable for use as cooked rice, whereas the classification process yields a flour of limited demand. Then too, overmilling fits into the regular rice milling operations. The amount of flour economically removed would be governed by a balance between increased value obtainable from the flour and costs arising from the added milling.

1/ Principal chemist, associate chemist, chemical engineer, and principal Chemist, respectively, Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

PANICLE INFECTION OF RICE BY HELMINTHOSPORIUM ORYZAE

Harry W. Schroeder and Syed Fazal Imam Fazli[1/]

The 1963 second crop of Belle Patna was generally of poor quality and yields did not reach the expected levels. Panicle infection by Helminthosporium oryzae Breda de Haan was identified as a major factor contributing to both reduced yields and poor quality. H. oryzae was isolated from up to 95 percent of the kernels in samples of second crop Belle Patna rice collected in the rice area, south and west of Houston, Tex. Subsequently, inoculation of sterile samples of Belle Patna and Bluebonnet rough rice with H. oryzae resulted in the development of kernel discolorations similar to those of natural occurrence. Under the conditions of the experiment, kernel discoloration developed at approximately the same rate in both varieties. Infected kernels, when parboiled, were identical in appearance to "pecky kernels" in parboiled rice.

Bluebonnet 50 rice was grown in the greenhouse and inoculated with a spore and mycelium suspension of H. oryzae at the flowering, milk, softdough, and mature-stage of kernel development. Four hundred seeds from each treatment were plated and H. oryzae was isolated from 26. 5, 26. 00, 9. 27, and 1. 50 percent of the seeds of the flowering to mature treatment stages, respectively. In comparison, the fungus was isolated from an average of 1. 37 percent of the noninoculated controls with no significant differences between the respective treatment controls.

Twenty-five grams of rough rice were harvested from each of the treatments and their respective controls. An analysis of these samples indicated that quantitative and qualitative losses resulted from inoculation with H. oryzae (table 1).

Table 1--The effect of inoculation of panicles of Bluebonnet 50 rice with Helminthosporium oryzae on yield and quality of brown rice[1/]

	Noninoculated	Inoculated
Number of kernels[2/]	949	862
Nondiscolored kernels		
Percent of total	95. 55	90. 77
Average kernel wt.[3/] (mg.)	19. 20	17. 58
Discolored kernels		
Percent of total	4. 45	9. 23
Average kernel wt.[3] (mg.)	12. 67	12. 64

1/ Average of 4 stages of maturity at time of inoculation.
2/ Based on shelling 25 g. rough rice.
3/ Based on weight of 35 kernels.

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There were no significant differences among maturities at time of inoculation in the noninoculated controls; however, damage decreased with increasing panicle maturity in the inoculated rice. The data showed that infection at flowering and milk stages of maturity resulted in failure of seed to set, increased percentage of discolored kernels, and a reduction in average kernel weight. These data indicated a minimum yield reduction of 30 percent as a result of severe infection at flowering time in addition to a marked decrease in quality from damaged (discolored) kernel prevalence. The development of the disease in epiphytotic form at early stages of panicle development can be expected to cause similar losses in the field.

Discolored kernels from the greenhouse experiment were sectioned and microscopically examined. The hyphae of the fungus appeared to be confined to the pericarp. No hyphae were seen in the endosperm tissues. However, hyphae of H. oryzae were found in close association with the embryo, although hyphae were not seen inside the embryo tissues.

Milled "packy" kernels of parboiled Belle Patna rice from a commercial source were also sectioned. The histopathological study showed mycelia throughout the endosperm with a mass of mycelia coating the surface of the endosperm. The mycelia appeared to follow a regular pattern in invading the endosperm tissue, apparently growing in the matrix binding the starch granules. The weakening of this matrix by fungal hyphae may explain the high percentage of kernel breakage during milling among kernels with moderate to severe fungal infections.

INHERITANCE IN RICE OF REACTION TO BLAST RACES 1 AND 6 [1/]

John G. Atkins and T. H. Johnston[2/]

Several pathogenic races of Piricularia oryzae, cav. the causal organism of the rice blast disease, are known to occur in the United States. An intensive testing and breeding program was initiated in the Southern rice area in 1959 to develop new rice varieties with resistance to these races. In this program varietal reactions to specific races of P. oryzae have been determined rather than simply varietal reactions to "blast." Races 1 and 6 have been used as key test races in greenhouse inoculations of varieties and selections. Studies of the inheritance of reaction to races 1 and 6 were made as a part of the coordinated blast program.

The following crosses were made at the Rice-Branch Experiment Station, Stuttgart, Ark.

Northrose x Zenith

Northrose x Gulfrose

Northrose-Nato x Gulfrose

F_1, F_2, and F_3 plants were grown at Stuttgart to produce seed to be used in these studies. The seedling plants to be inoculated were grown in a greenhouse at the Rice-Pasture Research and Extension Center, Beaumont, Tex.

P. oryzae isolates representative of races 1 and 6 were used in these studies. The parent varieties Zenith and Gulfrose are susceptible to race 1 and resistant to race 6. Northrose and Nato are resistant to race 1 and susceptible to race 6.

In tests with 98 F_2 plants of Northrose x Gulfrose, a good fit was obtained to a ratio of 3 resistant to 1 susceptible for both races 1 and 6. When the 98 plants were classified on the basis of individual reaction to both races, a very good fit to a 9:3:3:1 ratio was obtained.

Data from separate inoculations with race 1 and 6 of 298 F_3 lines of Northrose x Gulfrose gave a satisfactory fit to a 1:2:1 ratio, corroborating the results obtained in the F_2.

The F_3 reactions (based on inoculation of F_4 seedlings) of the other two crosses gave similar results with the data giving a good to very good fit to a 1:2:1 ratio.

On the basis of the crosses studied, the reactions to races 1 and 6 are controlled by two genes with resistance dominant. These genes provisionally are designated as Pi_1 and Pi_6.

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2/ Research plant pathologist and research agronomist, Crops Research Division, Agricultural Research Service, U.S.D.A.

FIELD AND GREENHOUSE BLAST REACTION TESTS[1/]

John G. Atkins[2/]

Since 1959 a large number of rice varieties and selections have been grown in the greenhouse for seedling reaction tests to the major races of *Piricularia oryzae*, cav. All of the U.S. rice varieties are susceptible to one or several races of *P. oryzae*. However, sources of resistance to each race known to occur in the United States have been found among these varieties. The collection of United States varieties and selections has been catalogued for reaction to the major races. Several sources of resistance to each of the races are available for use by the rice breeders.

Races 1 and 6 were used as key test races in screening varieties and selecting for resistance. Those showing resistance to race 6 in greenhouse tests were generally resistant in the field nurseries when race 6 was the prevalent race. Similarly, those resistant to races 1 and 6 in the greenhouse tests were resistant in the field nurseries where both races occurred. Most of the varieties and selections showing a high level of leaf blast resistance were also resistant to panicle blast.

C.I. 9540, Saturn, is susceptible to race 7 but resistant to the other races. C.I. 9534, a promising early, long-grain selection, is resistant to all of the races known to occur in the Southern rice area.

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RESPONSES OF CERTAIN RICE VARIETIES TO THE HOJA BLANCA VIRUS [1/]

H. A. Lamey[2/]

For several years the response of rice varieties to the hoja blanca virus has been observed in field plots in Latin America, and in greenhouse tests in Louisiana. Field plot observations include a 3-year test in which data were recorded on percent diseased plants and diseased tillers, as well as visual estimates on a 0-9 scale. The greenhouse tests, conducted in large inoculation cages, consisted in periodic confinement of rice plants with Sogata orizicola Muir, vector of the hoja blanca virus. Since only 10 percent of these insects are capable of virus transmission, such a dense population was used that plants had to be at least 6 weeks old before confinement. The average duration of these experiments was 124 days.

A replicated field test, known as the Hoja Blanca Strain Nursery, was grown in Colombia for 3 years. On the basis or percent diseased plants, percent diseased tillers, as well as readings on the 0-9 visual scale, varieties were classed as follows: Susceptible--Toro, Nato, Fortuna Bluebonnet 50, and Magnolia; Moderately Susceptible--Zenith and Century Patna 231; Moderately Resistant--Tainan-iku No. 487 (P.I. 215936), Sadri, Missouri R-500, and Arkrose; and Resistant--Pandhori No. 4 (C.I. 6001), C.I. 9431 (Lacrosse X C253), Colusa, C.I. 9543 and C.I. 9454 (Lacrosse X Zenith-Nira), Gulfrose, Lacrosse, and Asahi. The percent diseased plants (mean of 3 years) and percent diseased tillers (mean of 2 years) for several representative varieties were Bluebonnet 50, 80 and 68 percent; Nato, 78 and 79 percent; Arkrose, 49 (2-year mean) and 31 percent (1-year mean); and Gulfrose, 24 and 12 percent. Another replicated test, planted in Colombia in 1963, contained several varieties tested in the Hoja Blanca Strain Nursery, as well as some others. The mean percent diseased plants and diseased tillers for several varieties were Bluebonnet 50, 87 and 57 percent; Nato, 81 and 61 percent; Gulfrose, 5 and 11 percent; Dima, 60 and 23 percent; Krakti, 85 and 35 percent; Jojutla, 88 and 39 percent; and B.G. 79 (P.I. 185800), 26 and 7 percent.

Some of the same varieties were tested in greenhouse experiments. Bluebonnet 50, and either Arkrose or Gulfrose, were used as check varieties. The mean percent diseased plants for 56 tests conducted during a 2-year period was Bluebonnet 50, 71 percent; Arkrose, 3.7 percent; and Gulfrose, 0.5 percent. The greenhouse data for Bluebonnet 50 were in close agreement with field data, but greenhouse disease incidences for Arkrose and Gulfrose were lower than those from the field. This simplified the distinguishing of resistant from susceptible selections, although the tests may not have been quite as severe as field tests. Other varieties tested and their disease incidences were Dima, 66 percent; B.G. 79 and 67 percent, Jojutla, 85 percent; Krakti, 59 percent; and Nato, 54 percent. Results of tests on these varieties were in general agreement with field observations except for B.G. 79. Results on Dima and Krakti, although in agreement with 1963 field data, were at variance with 0-9 observations made prior to 1963 when hoja blanca incidence was lower. A number of Dima and Drakti plants had only 1 or a few diseased tillers, so the 0-9 ratings were low, indicating some resistance. In 1963 the incidence of diseased tillers was considerably lower for these varieties than for Bluebonnet 50 or Nato, but the incidence of diseased plants was only slightly lower. Apparently Dima, Krakti, and B. G. 79 possess a degree, type, or types of field resistance not readily demonstrable in the greenhouse.

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INHERITANCE AND RELATION TO YIELD AND HEIGHT OF FOUR MORPHOLOGIC CHARACTERS OF RICE[1/]

Nelson E. Jodon[2/]

The absence or gross differences in size of typical morphologic structures possibly influence the yielding ability of the rice plant. F_2 segregations and the yield and plant height of recovered lines which exhibited all combinations of four constrasted pairs of morphologic characters were studied in two crosses.

The F_2 segregation for presence or absence of pubescence (Gl:gl) and Ligules (Lg:lg) was controlled by single genes. Length of outer glumes involved a recessive gene for long-glume (G:g) in one cross and a semi-dominant (Gm:gm) in the other. Awning (An:an) was controlled by a single gene in the g cross, but the mode of inheritance in the Gm cross was not determined. Association between awns and pubescence in the Gm cross and liguleless and glabrous in the g cross probably was not chromosomal linkage.

All 16 possible combinations of the 4 pairs of characters were recovered in the F_5 and yield tests were conducted in single row plots in the F_6 generation.

Yield and height differences among strains were highly significant in each cross but correlation between tests was low. Correlation between height and yield within crosses was negligible. Normal linguled strains significantly outyielded the liguleless in both crosses. Normal short-glumed strains were significantly higher yielding than long-glumed in the Gm cross, but not in the g cross. Presence or absence of awns and pubescence was not related to yield.

Interaction occurred between the following pairs of characters in both crosses; awns and ligules, ligules and pubescence, and pubescence and glume length. Interaction between awns and pubescence was found in the g cross only. Two interactions in the Gm cross involved 3 pairs of characters; awns, ligules and long-glumes and pubescence, ligules, and long-glumes. The occurrence of significant interactions involving loci where there was significant difference between alleles (and the converse) was attributed to epistatic or complementary gene action.

No combination of characters outyielded the one agronomically preferred; awnless ligules, short-glume, and glabrous.

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INVESTIGATION OF PLANT CHARACTERISTICS POSSIBLY RELATED TO STRAW STRENGTH IN RICE[1/]

Charles N. Bollich[2/]

The relationship of culm diameter and unit culm weight to straw strength was studied in the F generation of a cross between P.I. 233096 and C.I. 7312, two selections from the U.S. Department of Agriculture World Rice Collection. P.I. 233096, an introduction from India, is a high tillering selection with narrow leaves, willowy straw, and moderately small culm diameter. It has low unit culm weight and breaking strength of straw. C.I. 7312, an introduction from the Phillippines, is a low tillering selection with broad leaves, stiff, erect straw, and large culm diameter. It is high in unit culm weight and straw strength.

Space-planted populations of the parents and F_2 population were grown at Crowley, La., in 1963. Growth of all plants appeared normal except that stem borers damaged numerous plants of C.I. 7312. At maturity, the main culm was harvested from each plant and culm diameter and breaking strength of straw--recorded as breaking index--were obtained immediately, i.e., on green culms. Straw strength was measured in the area 1 to 4 inches above the crown and culm diameter and unit culm weight were measured in the same area. Unit culm weight is based on the weight of a 1-inch cross-section of the culm.

For straw strength, culm diameter, and culm weight the F_2 plants were distributed in a unimodal curve, indicating a quantitative type inheritance for each character. For straw strength and culm diameter, the range of the F_2 population covered the ranges of both parents. For unit culm weight, the range of the F_2 population covered that of the smaller culm parent, but extended over only about one-half the range of the larger culm parent.

For straw strength, the coefficient of variability values were 38.5, 52.0, and 47.4 percent for P.I. 233096, C.I. 7312, and the F_2 population, respectively. These values are high and indicate that straw strength is subject to a strong degree on environmental variation. The higher coefficient for C.I. 7312, relative to that of P.I. 233096 or the F_2, may have been due to the extensive stem borer damage in that population. The P.I. 233096 parent was free of borers; therefore, the coefficient of variability for this parent is considered a more reliable measure of the environmental variation for all characters studied.

The total variation in unit culm weight in the F population was substantially less than that for straw strength--32.3 percent as compared to 47.4 percent. The coefficient of variability for culm weight was 16.3 percent for P.I. 233096, a value approximately half that of the F population. These results indicate that a relatively greater proportion of the variation in culm weight in the F was due to genetic causes than for straw strength.

Culm diameter was the least variable of the three characters studied. The coefficient of variability for P.I. 233096 was 9.2 percent and for the F_2 population, 14.2 percent--the greater portion of the variation apparently being due to environmental causes.

In the F_2 population, simple correlation coefficient values for straw strength x culm diameter, straw strength x culm weight, and culm diameter x culm weight, were 0.366, 0.371, and 0.274, respectively. These values are low and indicate that culm diameter and weight had only a minor influence on straw strength. The low correlation between culm diameter and culm weight

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suggests that the influences of these two characters on strength were relatively independent of each other. In the parent population, the correlation values were lower than in the F_2 population and were not significant statistically, whereas the values in the F_2 were all highly significant.

To estimate the variation in straw strength in the F_2 population that could be accounted for by culm diameter and unit culm diameter and unit culm weight, a multiple regression model was proposed that involved diameter and weight values, their squared terms, and the interactions. The multiple R^2 values obtained was 0.247, indicating that only approximately 25 percent of the variation in strength could be accounted for by variation in culm diameter and unit culm weight. These results indicate the existence of one or more culm characters of importance in straw strength in addition to culm diameter and weight.

A METHOD FOR WATER-SEEDING RICE-BREEDING MATERIAL[1/]

Joseph R. Thysell and Johan J. Mastenbroek[2/]

The commercial rice crop in California is sown directly into the water, but rice-breeding nurseries have been drill-seeded. Many lines that appeared to be quite satisfactory when drill-seeded, perform poorly when water-seeded because they do not emerge through the water satisfactorily or they lodged severely. For these reasons it was necessary to develop methods for water-seeding the breeding material and for conducting field trials.

In 1958, the first water-seeded plots were used to evaluate yield of rice varieties at the Rice Experiment Station, Biggs, Calif. Various materials such as sheet metal, plastic screen, and polyethylene have been used as levees to enclose plots. All of these materials were too costly and took too much time to install. In 1962, water-seeded rows were first used successfully. It was found that best results were obtained when the seed was soaked for 24 hours and then allowed to germinate for an additional 24 hours at 70 to 75°F. and when the irrigation water was at least 6 inches deep. When this is done, drifting within and between plots is minimal. In 1963, a trough was used for planting water-seeded rows. This made it possible to distribute the seed easier and evener in the row and to space the rows accurately. Also in 1963, it was found that by soaking the seed and with the proper water depth, water-seeded plots 6-feet x 6-feet and 6-feet x 12-feet could be used successfully. At the present time, studies are underway to determine the best size and shape of water-seeded rows and small plot for testing various kinds of breeding material.

In 1963, progeny rows and new varieties were grown in water-seeded row. This made it possible to evaluate the material for ability to emerge through the water, to get an indication of the amount of tillering, and to observe straw strength.

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SEEDLING VIGOR IN RICE [1]

C. Roy Adair [2]

Seedling vigor is an important character in rice and the development of varieties that emerge quickly and grow rapidly during the seedling stage is one of the objectives in rice breeding programs. This character is studied in field experiments but generally only observations are made and no quantitative data are obtained. Preliminary trials have been conducted under controlled conditions of temperature, moisture and light in an attempt to establish a method for evaluating seedling vigor. Such a method would permit classification of varieties on the basis of seedling vigor, selection of lines with seedling vigor, and association of seedling vigor with other important plant characters. A brief summary of one typical experiment designed to study seedling vigor is presented.

The experiment was conducted in a growth room. The temperature was maintained at $68^\circ \pm 2^\circ$ F., with 14 hours of light and 10 hours of darkness during each 24-hour period. The experimental design was quadruplicated, randomized complete blocks. Fairly fertile greenhouse potting soil was used. The seed was treated with a slurry of thiram and dieldrin at a rate of about 4 ounces per 100 pounds. Seeding was at the rate of 12 seeds per 3-inch pot and at a depth of one-half an inch. The seeding date was July 19, 1963, and the experiment was terminated August 2. The pots were irrigated twice a day so the soil moisture was near optimum at all times. The length from the seed to the tip of the longest leaf of each plant was measured. The average length of leaf for each pot was computed and the analysis of variance calculated from these values.

The 29 varieties included in the experiment included 28 varieties with C.I. numbers ranging from 8985 through 9020. C.I. 7787 was the check variety. The average length of longest leaf ranged from 111.5 mm. to 46.0 mm. The coefficient of variability was 11 percent and the difference required for significance at the 5-percent level was 9.9 mm. Compared with the check variety, the values for the 28 test varieties ranged from 90.4 to 41.2 percent. In this experiment the check variety was significantly taller than all test varieties and two of the test varieties were were significantly taller than the other 26 entries.

The results obtained in this and other similar experiments suggest that values obtained by this method of testing can be used for classifying the seedling vigor of varieties and breeding lines. The values could be recorded as percent of a standard variety.

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USE OF THE BIURET TEST IN A BREEDING PROGRAM FOR INCREASING THE PROTEIN CONTENT OF RICE[1/]

B. D. Webb[2/]

Previous reports presented at this meeting have indicated the interest shown in recent years in obtaining a rice grain with a higher level of inherent protein. A report[3/] was made describing experiments started in Arkansas in 1950 regarding the "high-protein" selections made from crosses with "low-protein" United States commercial varieties and "high-protein" varieties from India. Also reported were future plans to accelerate breeding and selecting for increased protein content through additional crosses with "high-protein" World Collection varieties.

Since a breeding program of this type would require screening large numbers of breeders' samples each year, a simple and rapid method was needed that would be effective in selecting breeding materials for higher protein content. For this need, attention was directed towards the colorimetric biuret test method described by A. J. Pinckney (Cereal Chem. 38: 50, 1961), and modified by A. C. Jennings (Cereal Chem. 38: 467, 1961), for empirically estimating the protein content of barley, wheat, and flour. In this method, extraction of the protein and color development occur simultaneously in an alkaline copper tartrate solution.

The biuret protein test method, as modified to meet conditions existing in the Regional Rice Quality Laboratory, was applied to brown and milled rice samples of 150 entries from plant breeders' advanced uniform nursery trials, outlying observation nurseries and World Collection varieties. Kjeldahl protein contents of these same entries were determined by the micro-Kjeldahl protein procedure using the factor 5.95 for converting percent nitrogen to percent protein. Kjeldahl protein contents of the various samples ranged from 5.5 to 10.5 percent and biuret absorbance values for test solutions of portions of these samples ranged from 0.350 to 0.710. Correlation coefficients were computed to determine the relationship between percent Kjeldahl protein and biuret absorbance values, and "r" values of 0.91 and 0.86 were obtained for milled and brown rice samples, respectively. Possible variations in the amount of extraneous alkali extractable brown-colored material (A. C. Jennings, Cereal Chem. 38: 467, 1961) present in the bran may have contributed to the lesser degree of correlation obtained for the brown rice samples.

Biuret test determinations have also been made on the selections from crosses between the "high-protein" rice varieties from India and "low-protein" United States rice varieties reported on previously The results obtained from this and other trials thus far indicate that the biuret pro tein test offers a satisfactory means of initially screening breeding material for "high-protein" or "low-protein" content. Following the initial screening of large populations of breeding materials with the empirical biuret test, the protein content and amino acid composition of the more promising selections will be determined, utilizing suitable methods of analysis.

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3/ Breeding for Higher Protein Content in Rice - A Progress Report. T. H. Johnston and B. D. Webb. Presented at the Rice Technical Working Meeting, June 1964.

BREEDING FOR HIGHER PROTEIN CONTENT IN RICE-- A PROGRESS REPORT[1/]

T. H. Johnston and B. D. Webb[2/]

Considerable interest has been evidenced in recent years in obtaining rice grain with a higher level of inherent protein content. At the meeting of the RTWG in 1960[3/], the senior author described experiments started in Arkansas in 1950 to increase the protein content of rice. Selections from crosses with the "high-protein" parent AdT_3 have been grown intermittently at Stuttgart, Ark., since 1954. A progress report on further studies follows.

1963 Results

About 80 entries were grown in 1963 in single 4-row, 15-foot plots. Protein (nitrogen) determinations were made at the Regional Cooperative Rice Quality Laboratory at Beaumont, Tex., using the Kjeldahl method of analysis. Of three AdT_3 "parent" strains grown, two classed as "high-protein" showed 10.6 and 10.8 percent protein, respectively, compared with only 7.8 percent for a "low-protein" strain. Grain yields from these three strains were almost equal and rough and milled rice samples were indistinguishable in appearance. A total of 8 strains of Zenith ranged from 7.3 to 8.5 percent protein.

Some hybrid selections have shown consistently high-protein content whereas others selected as low-protein lines have continued to show low levels of protein.

The yield of rough rice per plot versus the Kjeldahl protein content of brown rice showed an "r" value of -0.57, indicating that as the grain yield increased the protein content tended to decrease. Among individual entries in the study there were notable exceptions to this tendency, however. For example, the three strains of AdT_3 produced almost equal yields of grain but when the protein content of brown rice was converted to pounds per acre of protein, the high-protein lines showed 374 and 355, respectively, compared with only 243 pounds for the low-protein line.

Future Plans

In 1964, two variety tests were conducted at Stuttgart as a part of the continuing protein study. In one of these, 20 entries were included in quadruplicated 3-row plots. Entries included appropriate check varieties and high-protein lines of the crosses with AdT_3. The other test included about 60 entries from the group of World Collection varieties grown at Stuttgart in 1963, which were classed as fairly high in protein content.

Insofar as possible, efforts will be made to provide uniform and favorable conditions for growth of all entries in both of the above tests. Field notes will be taken and plant type and vigor will be noted to aid in evaluating entries for use as parents in the breeding programs.

Grain yields will be obtained in both tests and samples of each entry will be tested for various aspects of milling yield. The protein content will be determined by means of the Kjeldahl method and/or the biuret test using brown rice. Attempts will be made to study relationships of grain yield and protein content. Since previous tests have shown that protein content may be influenced to an appreciable extent by environmental conditions, the variability in protein content will be carefully noted.

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2/ Research agronomist and research chemist, Crops Research Division, A. R. S., U. S. D. A., Stuttgart, Ark., and Beaumont, Tex., respectively.

3/ Proceedings of the Rice Technical Working Group, 1960 meeting, February 1961, page 13.

ABSTRACTS ON DRYING AND STORAGE

SUMMARY OF RICE DRYING RESEARCH IN LOUISIANA

Macon D. Faulkner and Finis T. Wratten[1/]

This section on rice drying deals primarily with harvest moisture content and the relative merits of milling rice immediately after drying or after cooling and tempering.

In south Louisiana, rice harvesting at about 18 to 22 percent moisture content normally will result in highest milling yields. Harvest above and below these moisture content levels usually results in gradual lowering of head rice yields to the harvest moisture levels. However, under certain conditions of high or low relative humidity an increase or decrease in head yield may occur when rice is harvested below moisture levels normally considered consistent with high head yields.

During the 1962 harvest season, samples were harvested and threshed to determine mill yield from rice harvested at varying moisture content. These samples were taken for both Bluebonnet and Toro during conditions of high relative humidity and allowed to dry in shade to approximately 12 percent. Sampling and harvest were begun when the moisture content was approximately 25 percent and continued at 1-percent intervals to 12 percent for Toro and 15 percent for Bluebonnet. These samples were then milled and sized to determine head rice yield. Total yields were also recorded but with little variation due to harvest moisture considered.

In both cases head rice yields increased as moisture content decreased. For Toro the relationship between harvest moisture content and head rice yield may be expressed as $y=ax+b$ a linear relationship, where y - head rice yield in percent.

a,	a constant	=	(-0.5)
b,	a constant	=	71.75
x		=	moisture content percent

The relationship for Bluebonnet is expressed as $y=ax+b - ce^{dx}$

y		=	head rice yield in percent
a,	a constant	=	-0.68
b,	a constant	=	73.2
c,	a constant	=	3.48×10^{-7}
d,	a constant	=	0.692
x		=	moisture content percent

As mentioned previously, head rice yields increased as moisture content decreased during this period of high humidity. However, during extremely dry weather, the relationship may be expected to reverse. Whereas, during normal (south Louisiana) weather, highest mill yields would occur at 18 to 22 percent harvest moisture content.

With the work conducted on mill yields and harvest moisture, and its implications, the next obvious step is to attempt to predict, not only the optimum moisture content for harvest under normal conditions, but also under conditions other than normal. This will be the next step in this work at the Louisiana State University Rice Experiment Station at Crowley.

Another area of work related to mill yield, as mentioned earlier, is on milling rice either immediately after drying or

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allowing the rice to cool and moisture within the grain to distribute prior to milling. This work was done by taking random samples of rice as it was discharged from the drier and milling them immediately, and by allowing samples taken from the drier at the same time to cool for a minimum of 24 hours and then milling. Comparisons were then made between milling yields obtained from the two to determine what, if any, advantage would be gained by milling soon after drying.

Research has indicated that an increase in head rice yields can be expected with a decrease in moisture content. Since rice dries from the outside, a dry layer should exist at the grain surface immediately after exposure to drying conditions. This condition would possibly lend itself to high head yields without removing moisture from the entire grain. This assumption, however, did not prove to be correct. In the three varieties considered, no trends or advantages were apparent in either of the cooling intervals considered.

Some research has indicated that long periods of storage--over 3 weeks--will increase mill yields, however, periods longer than 24 hours were not considered in this work.

RICE DRYING IN LOUISIANA

M. D. Faulkner and F. T. Wratten[1/]

Drying studies at the Louisiana Agricultural Experiment Station are designed to evaluate intermittent drying techniques with respect to length of drying interval, maximum or optimum drying air temperature , veolcity of air through the rice, thickness of the rice pack, initial moisture of the rice, and length of the conditioning period.

Even though there has been a considerable amount of excellent research work conducted along these lines, we are not yet able to accurately prescribe optimum conditions for drying. It is generally conceded that a good job of drying can now be accomplished with the present state of knowledge but limits of the various parameters, such as drying air temperature and thickness of rice column, have not been completely established with respect to mill yield and economics of the system. The principal advantage to be obtained from the intermittent system for drying is a reduction of the total time in the drying column, and this advantage must be weighed against mill yield, volume or space requirements, number of passes, etc., in order to establish optimum conditions for drying.

Previous work utilizing radio-frequency (dielectric) energy as a source of heat energy for drying had indicated that milling quality was affected by the amount of moisture removed per pass but was not appreciably affected by drying air temperature or length of pass, except as a means of controlling the amount of moisture removal per pass. More recently, Schroeder, U.S.D.A., at Texas A. & M., reported work with infrared as a source of heat energy. These results also tend to indicate that there is some limit of moisture removal per pass beyond which milling quality is lowered. Since radio-frequency drying used relatively short (5-minute) drying intervals and the infrared drying system used extremely short (few seconds) drying intervals, the use of a short drying interval for conventional drying may decrease total time in the dryer and thereby increase the dryer output. Too, previous work has indicated the possibility of using preheating as a means of improving dryer output and was, therefore, included in the present work.

A sample dryer, designed to provide simultaneous drying of 10 samples, was used to dry a series of samples for each of two long-grain varieties of rice, Bluebonnet 50 and Toro. Each drying series consisted of seven air temperatures from 120° to 240° F. in 20° increments and four drying intervals of 2, 5, 10, and 15 minutes at each air temperature. The ventilating air rate was adjusted to provide 100 c.f.m. per sq. ft. of sample cross sectional area and the initial weight of all samples was approximately 4 pounds which produced a sample of approximately 6 inches in depth. In addition to the above series, a number of samples in closed containers were preheated at 120° F. up to 24 hours and used in a drying series in which the drying of the preheated samples was compared to drying of samples initially at ambient temperature. Temperature within the drying samples was also used as a means of comparing the conditions of preheat and no-preheat drying systems.

Results indicate that for the 6-inch depth of rice used, milling quality connot be predicted on moisture removal per pass only, but is a function of air temperature and length of drying interval as well. Total time in the dryer was minimum when the longer drying intervals of 10 and 15 minutes were used. This result is a reversal of that previously obtained using radio-frequency energy in which the shorter drying intervals resulted in less total time for drying. Air temperatures above 140° F. were excessive for

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the conditions used. A reduction in total drying time was produced by preheating the samples prior to drying.

The above results of work utilizing a 6-inch depth of rice when compared to earlier work with 2-inch depth and to the infrared work with single grain thickness lead to the conclusion that more information is needed to relate depth of rice and velocity of air to the other parameters for drying. Temperature within the rice while drying may well prove to be a very valuable tool for analyzing the effects of drying parameters. More work is needed to evaluate the possibility of using a shallow depth or higher air velocity. Preheat techniques need also to be studied to determine if advantages for drying exist in this area.

SOME ASPECTS OF RICE PROCESSING IN INDIA

Macon D. Faulkner[1]

India produces rice on approximately 80 to 85 million acres. From this acreage about 50 to 58 million metric tons of rough rice are available for seed and consumption. The 50 to 58 million tons yield roughly 30 to 35 million tons of clean milled rice. Estimates indicate that milling yields average around 58 percent total clean rice from paddy taken to commercial mills.

This yield of 58 percent is from milling procedures that only remove 3 to 7 or 8 percent bran, which indicates that large amounts of rice are being lost into hulls and dust.

Low yield in Indian mills can be briefly attributed to:

(a) Low yielding varieties

(b) Harvesting and threshing methods.

(c) High percentage of red rice and off-types.

(d) Poor cultural practices.

(e) Drying procedures.

(f) Storage methods.

(g) Milling equipment and methods.

Typically, rice in India is harvested by hand cutting, then drying in open air where it is exposed to wetting and drying in direct sunlight. In many cases, drying is either done in conditions of extremely high temperatures and low humidity or high temperatures and humidity. Under conditions of low humidity, the grain cracks and losses occur in milling. Under high humidity conditions adequate drying is impossible; consequently, losses occur in storage.

After drying, the rice is then threshed partially by flailing and partially by trampling. Again, the grain is exposed to prevailing ambient weather conditions. The grain, after threshing, is usually stored in the farmers' compound or taken immediately to market and stored until it is milled. In no instance of farmer or commercial storage has a planned program of insect, bird, or rodent control been evident. Consequently, losses of from 5 to 10 percent of the rough rice may occur due to poor storage conditions. The Government of India does maintain a number of warehouses, where a planned approach to "in storage" grain protection is attempted.

Red rice and off-type varieties are a common problem in India. The problems associated with milling mixed varieties, leads to losses of rice due to the inability to adjust equipment and reduce breakage.

Approximately 20 to 25 percent of the rice in India is parboiled prior to milling. Parboiling is done by soaking rough rice in any available water at ambient temperatures for 24 to 48 hours, then steaming for 15 to 30 minutes. After parboiling, the rice is placed on a drying floor for 6 to 8 hours. During this drying process as much as 1/2 to 3 percent is lost to birds and rats.

The parboiling procedure used is ideal for fermentation and bacterial growth. Rice parboiled using the above-described procedures can be readily identified by its dark brown color and odor of fermentation.

Indian commercial milling equipment is patterned after European made machinery of 30 to 50 years ago, with many mills in use this old. The milling equipment being manufactured now has wide dimensional and quality tolerances. This situation leads to heavy

1/ Assistant professor, Agricultural Engineering, Louisiana State University, Rice Experiment Station, Crowley, La. The study and report from which this summary was taken, was made while the author was a consultant on grain processing with the Ford Foundation in India. The report was made in association and close cooperation with Dr. Dorris D. Brown, agricultural economist, Ford Foundation, New Delhi, India, and Mr. George W. Reid, consultant on rice milling, Ford Foundation, New Delhi, India.

losses into the hulls as dust, since the rough rice is broken from farm handling or during milling. Inadequate separation equipment will not recover small brokens.

Approximately 15 to 20 million metric tons of rough rice are milled at these commercial mills each year with an estimated 58 percent total mill yield. Good milling procedures and equipment along with improved production practices could increase this yield figure to 68 to 74 percent.

In addition to the 15 to 20 million tons of rice milled commercially, another 29 to 33 million metric tons are milled by hand pounding and are consumed locally. The hand pounding method of milling results in mill yields of about 48 to 50 percent total rice with high percentages of brokens.

It is reasonable to estimate that with 1/2 to 3 percent lost in drying, 5 to 10 percent lost in storage, and an average mill yield of 58 percent, that 25 percent or more of the rough rice produced in India is lost before it reaches the consumer.

No one procedure, technique or piece of equipment can solve this problem of massive food loss. The approach to a solution must be such that it includes better production practices, improved varieties, better seed, more fertilizer, improved harvest, storage and handling as well as better milling techniques and equipment.

The Government of India is aware of these losses and is making an effort to improve the conditions that lead to the loss of food to a people that is so short of food grain.

A PHYSICAL TECHNIQUE FOR MEASURING THE COLOR OF MILLED RICE

R. A. Stermer[1/]

Color or general appearance is one of the principal factors used to determine the grade of milled rice. Present methods of determining this factor depend upon visual judgment. The appearance of the rice is subject to variance with changing lighting conditions which may influence the rice inspector's judgment.

Studies are underway in the Agricultural Research Service's research laboratories at College Station, Tex., to develop an instrument for objective measuring color of rice. Since a rice photometer using light transmittance techniques has been developed to measure the degree of milling, it would be advantageous to use the same instrument for color measurement. Studies of samples of milled rice representing a wide range in color failed to show significant differences in their spectral transmittance. However, reflectance measurements showed that there was a considerable difference in total reflectance of lightness.

Studies were made of the tristimulus color factors of a large group of samples with a wide range in color, degree of milling, and other factors. A Hunterlab Model D25 Color Difference Meter equipped with a large area optical unit was used to measure the tristimulus color factors "L", "a" and "b". The "L" factor is a measurement of lightness; the "a" factor, a measurement of the redness versus greenness; and the "b" factor, a measurement of the yellowness versus blueness. Another factor for color difference measurements is total color difference measurements is total color difference, "ΔE". This is a computed value which combines all of the tristimulus color factors. The formula is $\Delta E = (\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2$ 1/2 where ΔL, Δa, and Δb represent the deviations from the particular color standard used.

Detailed studies were made of 75 samples of white milled rice obtained from the rice inspection office at Stuttgart, Ark. The samples were furnished with official visual grades of color, visual degree of milling, percent brokens, and variety.

Transmittance and reflectance measurements were made on these samples and simple linear correlation comparisions were made. The important correlation coefficients are shown in table 1.

This shows that the visual color is highly influenced by all tristimulus color factors. Lightness, Hunter "L", correlated highest with visual color. Total color differences, Hunter "ΔE", also correlated very highly.

Since lightness is the simplest and easiest of the color factors to measure, experiments were conducted with various simple optical arrangements and electronic circuits to measure this factor. After considerable testing, a design using diffuse 45° reflectance optics was chosen for further study.

It was found that two lamps are necessary to provide uniform illuminations of the sample. Twenty-watt airplane reading lamps, Westinghouse type 1387, are used since they have an internal parabolic reflector that provides nearly parallel light. A 1P39 phototube with S-4 spectral response is used as a detector. The spectral response of the phototube is corrected to simulate the spectral sensitivity of the human eye by using a Corning No. 3304 glass color filter.

The measuring circuit chosen consists primarily of a Wheatstone bridge circuit with the phototube in one arm of the bridge. Two stages of amplification are used to provide the

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Table 1. --Correlation coefficient of color and degree of milling factors.

Factors	Visual color	Rice photometer reading	Hunter "L"	Hunter "a"	Hunter "b"	Hunter "ΔE"
Visual milling	0. 045*	0. 898	-0. 099*	0. 674	0. 375	0. 173*
Visual color		-0. 149*	-0. 946	-0. 520	-0. 861	0. 938
Rice photometer reading			0. 109*	0. 827	0. 544	-0. 033*
Hunter "L"				0. 520	0. 821	-0. 996
Hunter "a"					0. 842	-0. 452
Hunter "b"						-0. 803
Hunter "ΔE"						

*Not significant; all others significant at the 99 percent confidence level.

desired sensitivity. Automatic temperature compensation is provided for in the circuit by having the amplifier tubes operated with a common cathode. A zero adjustment permits balancing the bridge circuit for differences in gain of the two amplifiers. Temperature variation of the phototube causes some drift of the instrument. The adjustment provided for calibration of the instrument with a suitable standard also allows adjusting for temperature changes of the phototube. The lightness is read on a turns counter connected to a 10-turn potentiometer which is adjusted until a null balance is obtained on the meter.

A prototype model of the experimental lightness meter was tested with a large number of white and parboiled rice samples. The correlations of visual degree of color versus the experimental lightness meter was very high (r = -0. 921) for white milled rice. The rather wide range of experimental lightness meter readings for a given visual index of color exists because of true color differences. It is believed that the points would actually fall closer to the regression line if the rice inspector were to array the samples from lightest to darkest and assign closer values such as 4. 5 for a sample which is a borderline sample between visual grade 4 and 5. Repeated measurements of the same sample of rice showed the experimental lightness meter to have a standard deviation from the mean of 0. 059.

The correlation coefficient was somewhat lower (r= -0. 740) for parboiled rice. This can be attributed partly to the fact that there were only three visual degrees of parboiling, with a majority of the samples being either parboiled light or parboiled. Preliminary studies show that degree of milling contributed to variation in color of white rice and to degree of parboiling of parboiled rice. The amount of broken rice in a sample contributed little, if any, to color variation but variety apparently contributed significantly to degree of parboiling.

Studies are underway at present to combine the experimental lightness meter with the rice photometer so that both quality factors can be obtained with one instrument. The Hunterlab Model D25 Color Difference Meter can be used to measure color but fails to provide a good measurement of degree of milling. Further studies are also being made to determine if a measurement of some color factor other than lightness will provide a better index of degree of parboiling.

THE USE OF GAMMA IRRADIATION FOR THE CONTROL OF INSECTS AND MITES IN STORED PRODUCTS

Elvin W. Tilton, Wendell E. Burkholder, and Robert R. Cogburn[1/]

Considerable amount of research by many workers has been directed toward the determination of the effects of gamma radiation on the various stored product insects and the products which they infest. The technical feasibility of using gamma radiation has been established; however, before this method can be used as a practical insecticide on a commercial basis, considerable information regarding dosages and techniques must be obtained. The problem is further complicated by the fact that there are two distinct goals--first, the need to provide adequate protection for raw cereal grains by breaking the reproductive cycle of the various species of insects by sexual sterilization; and second, to determine the necessary levels required to provide immediate mortality of the insects to terminate hidden infestations of all immature stages prior to further development in packaging plants.

During 1963 and 1964 an intensive study of the effects of gamma radiation on the mortality and fertility of 8 insect and 1 mite species was conducted at the Stored-Rice and Dairy Products Laboratory at Fresno, Calif. Insect species used were the lesser grain borer, Rhizopertha Dominica F., confused flour beetle, Tribolium confusum duV., rice weevil, Sitophilus oryzae L., Indian-meal moth, Plodia interpunctella Hubner, cigarette beetle, Lasioderm serricorne F., Angoumois grain moth, Sitotroga cerealella Olivier, black carpet beetle, Attagenus piceus Olivier, Trogoderma glabrum Herbstat., and the grain mite, Acarus siro L.

Radiation dosages used were 13, 200, 17, 500, 25, 000, 45, 000, and 100, 000 rads, and a fractionated treatment consisting of 10, 000 rads repeated at hourly intervals to obtain a total of 50, 000 rads. After the fractionated dosage had been used for 5 species of beetles, the data indicated that this method of irradiation did not offer sufficient promise to continue its use, so this treatment was dropped.

All metamorphic stages of the test species were used. Individual specimens were isolated in gelatin capsules with a minimum amount of food. A preliminary experiment with confused flour beetles indicated that the use of sealed gelatin capsules did not influence mortality of the irradiated insects. Previous research by other workers had indicated that the older an insect is within any given stage of its development the more resistant it is to irradiation; therefore, all insects used were as old as was practical for testing purposes.

Beetles treated at 25, 000 rads and above did not reproduce. Limited reproduction by the 2 moth species occured at all dosages used. The cheese mite reproduced after a dosage of 25, 000 rads, but not after a dosage of 45, 000 rads.

For all insect species the most susceptible stage was the eggs, followed by the larvae, then the pupae, and the adults were the most resistant.

No dosage used was high enough to cause immediate death of the adults of any test insect.

If gamma irradiation is to be used in packaging plants for the destruction of eggs and young larvae, it is possible that practical dosages can be determined.

For use in the treatment of rough rice to break the reproductive cycle of the insects, it is also possible that a practical dosage can be determined since the dosage required for sexual sterilization is much lower than the dosage required for immediate mortality.

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LABORATORY EVALUATION OF BAYER 29493

USED FOR THE PROTECTION OF ROUGH RICE AGAINST INSECT ATTACK

Elvin W. Tilton and Robert R. Cogburn[1]

A laboratory evaluation test of Bayer 29493, O,O-dimethyl O- [4-methylthio)-m-tolyl] phosphorothioate, as a protectant for stored rice was conducted during 1961 and 1962. Bluebonnet rough rice was treated with Bayer 29493 at intended dosage rates of 7, 14, and 21 p.p.m. Malathion at an intended dosage rate of 21 p.p.m. was included as a standard.

Bayer 29493 was an effective treatment for protecting the rice and compared favorably with Malathion in this respect. The dosage of 7 p.p.m. of Bayer 29493 protected the rice for a period of at least 6 months, and dosages of 14 and 21 p.p.m. protected the rice for 12 and 15 months, respectively. Treatment with 21 p.p.m. of malathion rendered good protection to the rice through 18 months' storage, although reduced protection was evident at this time.

Bioassays indicated that both protectants were transported onto the rice kernel and were retained in the rice bran and milled rice. It was not determined whether the protectant residues occurring in the bran and milled rice were a result of contamination during milling or a result of protectant migration during storage. Residues occurred in the rice bran and milled rice of those samples that were milled immediately after treatment, indicating that if its occurrence in these milling fractions was due solely to migration, such migration occurred rapidly. Methods of chemical analysis for Bayer 29493 were not available, so the proportion of the material retained in each milling fraction is not known.

The germination, bushel weight, and head rice yield were unaffected by the dosages of Bayer 29493 and malathion which were employed in these tests.

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USE OF AERATION FOR MAINTAINING QUALITY OF UNDRIED RICE [1]

David L. Calderwood[2]

Rough rice must be dried to about 12-percent moisture content (wet-basis) before it can be stored in bulk for long periods of time without risk of damage resulting in discolored kernels. These kernels are classified as "damaged" or "heat damaged", depending upon the type and degree of discoloration. The presence of either kind of kernel has a bearing on the U.S. Grade and the market value of the lot of rice from which the sample was taken.

The movement of a sufficient volume of air through rice in bulk storage will maintain the rice temperature at the same level as ambient air temperature. This will prevent spontaneous heating and retard the rate of spoilage. Under usual atmospheric conditions an air flow rate of 10 cubic feet per minute (c.f.m.) per barrel will dry rice before any spoilage occurs; however, much smaller rates of air flow will keep undried rice at ambient temperature and allow it to be placed in bulk storage for a limited period of time before appreciable damage occurs.

A series of tests were initiated in 1961 to determine how long undried rice could be stored under various conditions before enough damage occurs to change the U.S. Grade, based on presence of damaged kernels, from No. 1 to No. 2. The variables, which are believed to affect storage conditions, are rice variety, initial moisture content, ambient temperature, and air flow rate. The complete series of tests will include three or four batches of rice of each of the following varieties: Belle Patna, Bluebonnet 50, Nato, and TP 49. The initial moisture contents for batches of each variety will be in the range from 18 to 24 percent. Each batch is loaded into aerated bins of one-barrel capacity. Air flow rates of 1/2, 1, and 2 c.f.m. per barrel are provided for each batch. Temperatures of the rice in bins and of the surrounding air are recorded periodically.

The data taken through the 1963 harvest season are summarized in the following table: One or two additional batches of each of the four varieties should be stored before tests are complete. Incomplete data for Bluebonnet 50 aerated at 0.5 c.f.m. per barrel indicate that safe storage time ranges from 2 days for rice at 23 percent moisture content to 12 days for rice at 18-percent moisture content when the average air temperature is between 77° F. and 80° F. However, TP 49 rice at 19.6 percent moisture content remained at No. 1 grade for 22 days at a time when the temperature averaged 68° F.

1/ Cooperative investigations of Agricultural Research Service, United States Department of Agriculture, and the Texas Agricultural Experiment Station.

2/ Agricultural engineer, Transportation and Facilities Research Division, Agricultural Research Service, U.S.D.A., Beaumont, Tex.

Storage time of undried rice before change in grade was noted.

Variety	Initial moisture content (Wet-basis)	Average ambient temp.	Days storage prior to grade change		
			0.5 CFM	1.0 CFM	2.0 CFM
	Percent	Degrees F.	No. days	No. days	No. days
Belle Patna	22.2	84	3	4	-
Belle Patna	21.2	80	6	6	-
Nato	22.7	84	2	3	3
Nato	20.9	77	7	8	8
Bluebonnet	23.5	80	2	5	5
Bluebonnet	18.5	77	12	15	15
TP 49	21.9	76	3	7	11
TP 49	19.6	68	22	22	22

TESTS OF DRYING PROCEDURES USING A COMMERCIAL-TYPE RICE DRYER 1/

David L. Calderwood 2/

Drying methods have been tested for several years at the Rice-Pasture Research and Extension Center, Beaumont, Tex., using a continuous flow, heated air, column-type dryer. This dryer is similar to commercial dryers except for being smaller in size. Tests have been run in this dryer to provide information for assisting commercial dryer operators.

A series of 12 tests was run during the 1963 harvest season to determine the effect of two different through-put rates upon dryer operation time and milling yield of the dried rice. The air temperature control was adjusted so that rice emerged from the dryer at a predetermined temperature following each pass. Tests using Nato rice included nominal through-put rates of 1.2 and 2.0 barrels per minute with rice at temperatures near 100° F., 110° F., and 120° F. for each rate, respectively. Similar tests were run using TP 49 variety rice.

The results of these tests are shown in table 1. For any of the three temperatures, rice with a 2.0 barrel per minute through-put rate required less dryer operation time than did rice flowing through the dryer at the rate of 1.2 barrels per minute. The milling yield generally was better for samples from lots that were dried using the faster through-put rate.

Nato, a medium-grain rice variety, has the reputation of being difficult to dry. At the same time more acreage in Texas was planted to Nato than any other variety in 1963; consequently, there was a demand from commercial dryer personnel for information about drying procedures that would speed the drying of this particular variety. An obvious method of speeding the rate of drying of any variety is to apply more heat and take the risk risk of reduced milling yields.

Table 2 was prepared to show how the milling yield of the Nato variety rice was affected by using different drying temperatures. These are temperatures of rice. The temperature of the heated air was higher in all cases. Except for temperatures of air and rice, the drying procedures were the same for all lots; a through-put rate of 2 barrels a minute was used (exposure time of rice to heated air was 15 minutes during each pass through the dryer), and all lots were cooled to ambient air temperature by aeration while stored in bins during tempering periods between passes through the dryer. It may be noted that dryer operation time was substantially reduced by using higher temperatures, and that change in milling yield was negligible for rice temperatures up to 119° F.

1/ Cooperative investigations of Agricultural Research Service, United States Department of Agriculture, and the Texas Agricultural Experiment Station.

2/ Agricultural engineer, Transportation and Facilities Research Division, Agricultural Research Service, U.S.D.A., Beaumont, Tex.

Table 1.--Effect of rice temperature and through-put rate upon drying time and milling yield.

Lot	Initial moisture content (wet-basis)	Rice[1/] temp. in dryer	Through-put[2/] rate per minute	Passes through dryer	Operation[3/] time to evaporate 1,620 lbs. of water	Milling yields[4/] Heads		Total	Change[5/] in heads
	Percent	°F.	Bbls.	No.	Hours	Percent		Percent	Percent
Nato									
A63	23.5	119	1.2	4	3.5	58.5	-	68.0	-3.0
B63	22.2	118	2.0	4	2.9	63.5	-	70.0	-1.0
C63	22.2	110	1.2	4	5.2	60.0	-	68.5	-4.0
D63	22.5	109	2.0	5	3.4	62.0	-	69.5	-4.0
E63	21.7	103	1.2	5	6.4	63.0	-	69.0	-2.0
F63	22.2	103	2.0	7	4.9	64.5	-	71.0	-1.5
TP49									
G63	18.3	118	2.0	2	2.7	43.5	-	69.0	-4.5
H63	18.3	119	1.2	2	4.6	42.5	-	60.0	-6.0
I63	19.4	109	2.0	3	3.4	47.0	-	69.0	-1.0
I63	20.2	109	1.2	3	5.4	46.0	-	68.0	-6.5
K63	19.0	101	2.0	4	4.4	44.0	-	67.0	-5.0
J63	18.4	105	1.2	3	6.1	46.5	-	69.5	-1.0
Average for all lots with fast through-put rate					3.6				2.8
Average for all lots with slow through-put rate					5.2				3.7

1/ Temperatures are averages for samples taken at 10-minute intervals during each of several passes.

2/ Through-put rates of 1.2 and 2.0 barrels per minute resulted in exposure times of rice to heated air of 25 and 15 minutes, respectively, during each pass in dryer having a nominal capacity of 30 barrels.

3/ Because of differences in sizes of lots and initial and final moisture contents, the equivalent times for evaporating 1,620 pounds of water (the amount removed in drying 100 barrels of rice from 20 to 12 percent moisture content) are tabulated to make all lots comparable.

4/ Milling yield determinations were made by the Rice Inspection Service, Grain Division, AMS, USDA, Beaumont, Tex. on samples taken during the final drying pass.

5/ Samples from dryer are compared with samples taken before the remainder of lots were exposed to heated air in dryer. The latter were dried slowly by exposure to air heated 5 °F. above ambient air temperature.

Table 2. --The effect of temperature on dryer operation time and milling yield for Nato variety rice

Lot designation	Rice[1/] temperatures		Operation[2/] time to evaporate 1,620 lbs. of water	Milling yield[3/]			Change[4/] in heads after drying
	Enter dryer	Leave dryer		Heads		Total	
	°F	°F	Hours	Percent		Percent	Percent
F63	84	103	4.9	64.5	-	71.0	-1.5
D63	87	109	3.4	62.0	-	69.5	-4.0
B61	80	110	4.2	62.0	-	67.5	-3.0
D61	78	111	4.5	63.5	-	69.0	-1.0
F61	82	112	4.6	61.5	-	67.5	-2.0
A61	82	116	4.0	61.5	-	68.5	-3.5
E61	81	116	3.4	61.5	-	67.5	-2.0
B60	84	117	3.4	64.0	-	69.0	-2.5
B63	87	118	2.9	63.5	-	70.0	+1.0
C61	78	119	3.7	62.0	-	68.0	-2.0

1/ Temperatures are averages for samples taken at 10-minute intervals during each of several passes.

2/ Because of difference in sizes of lots and initial and final moisture contents, the equivalent times for evaporating 1,620 pounds of water, the amount removed in drying 100 barrels of rice from 20- to 12-percent moisture content (wet-basis) are tabulated to make these operations comparable.

3/ Milling yield determinations were made on the samples taken during the final drying pass by the Rice Inspection Service, Grain Division, Consumer and Marketing Service, U. S. D. A., Beaumont, Tex.

4/ Dryer samples are compared with samples taken before the remainder of the lot was exposed to heated air in dryer. These were dried slowly by exposure to air heated 5°F. above ambient air temperature.

ABSTRACTS ON ECONOMICS AND MARKETING

ECONOMIC EVALUATION OF RICE DRYING FACILITIES IN LOUISIANA AND TEXAS 1/

Harlon D. Traylor 2/

In recent years growers have expended approximately $15 million annually for rough rice drying and storage. Yet many facilities, constructed to perform these functions and representing substantial investment, lie idle or are only used at a fraction of capacity.

To develop more definite knowledge concerning why some facilities are successful, and presumably efficient, and others are not, this study presents the 1959-62 cost and other selected experiences of 95 sample dryers consisting of four selected types. The The four types of facilities selected for analysis were

(1) on-farm round stationary bulk bins,

(2) on-farm buildings with stationary bulk bins,

(3) on-farm multipass, continuous flow dryers, and

(4) off-farm or commercial type dryers.

For each type of facility, both plant and non-plant cost considerations were determined for several market situations.

Assuming, among other assumptions, that long-run average costs to growers are indicated by the experience of those plants operating at 80 percent of capacity or more, the data imply:

(1) farm multipass dryers are more efficient in each of three market situations studied than any of the other types of facilities,

(2) building with bulk bin type dryers are least efficient, and

(3) commercial and bulk bin type dryers are of about equal efficiency except for one marketing situation.

When selling rice on the open market after storage, round bulk bins appear to have a slight advantage over commercial facilities. Table 1 summarizes these findings.

While the average value of rice resulting from the different types of facilities generally was not significantly different, the large amount of variation between different lots tested raised several additional questions. Such average differences as did exist tended to be in favor of the stationary bulk bins after drying only, tending to disappear after storage. Multipass facilities tended to produce a slightly better average grade and total milling yield while the stationary bulk bins tended to produce a slightly better average head rice milling yield.

1/ Based on a study conducted jointly by the Farmer Cooperative Service, U. S. D. A., and the Louisiana Agricultural Experiment Station.

2/ Associate professor, Department of Agricultural Economics and Agribusiness, Louisiana State University, Baton Rouge, La.

Table 1.--Estimated long run average costs to growers for drying and storing rough rice by type of facility and marketing system as indicated by cost experiences of a sample of plants operating at 80 percent of capacity or more, 1959-62.

Marketing systems and summary cost items considered	Type of facility: On-farm: Round bulk bins	On-farm: Buildings with bulk bins	On-farm: Multi-pass	Commercial
	Cents per cwt.	Cents per cwt.	Cents per cwt.	Cents per cwt.
Selling grain immediately after drying				
In-plant drying	31.9	41.0	24.6	32.5
Other considerations	10.1	10.1	8.9	8.9
Total	42.0	51.1	33.5	41.4
Selling grain after storage				
In-plant drying	31.9	41.0	24.6	32.5
In-plant storage	--	--	--	10.3
Other considerations	23.1	23.1	25.0	25.0
Total	55.0	64.1	49.6	67.8
Forfeiting grain under the government price support loan program				
In-plant drying	31.9	41.0	24.6	32.5
In-plant storage	--	--	--	--
Other considerations	22.6	22.6	23.7	54.6
Total	54.5	63.6	48.3	54.6

RICE DISTRIBUTION PATTERNS

Marshall E. Miller[1]

Studies of rice distribution in the United States show that 15.8 million hundred weight of milled rice were distributed in the domestic continental market in the 1961-62 marketing year, a gain of 3.3 hundredweight over total distribution in the 1956-57 marketing year. Per capita consumption climbed from 5.8 pounds to 7 pounds. Gains occurred in each major sector (type of use) of the rice market.

On a state basis, California is the largest market, followed by New York, Louisiana, Texas, and South Carolina. A rising trend in rice use was noted in a number of States where distribution has been very low in the past. The increase in the size of the domestic market appears to have been caused by the expanded sales effort on the part of the industry. Maintenance of per capita consumption alone means a larger domestic rice market of the future. The response of rice sales to promotional efforts and the appearance on the market of a number of new rice products are positive factors which may mean some further increase over population gains.

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COMMON MARKET OPERATIONS AS RELATED TO RICE

Robert A. Bieber[1/]

EEC Producing Countries

Italy and France are the only rice producers in the European Economic Community. During the 1955-1963 period, Italy's production has averaged 600,000 metric tons, milled, and France's 74,000 metric tons.

Italy is the only major exporter of rice within the group. The Italian production is nearly equal to consumption requirements of the area. But Italy produces primarily a short-grain rice with only a limited amount of semi-long grains which, however, have the soft characteristics of short grains. Nowhere within the area is a type of rice grown similar to long grains exported by the United States. The heaviest importer of the type of rice grown in Italy is West Germany, although less than 50 percent of consumers' requirements is for short grain and the balance largely for long grain. The United States has been supplying most of both West German requirements. This trade has been largely centered volume-wise in brown rice of both short- and long-grain varieties.

In the Netherlands, Belgium, and Luxembourg, the share of imports of rice similar to the type produced in Italy does not exceed 20 percent, with the balance consisting of long- and medium-grain varieties in the order stated.

This means that the European Common Market area (assuming that France is self-sufficient with the aid of imports from Madagascar) is a deficit area for long- and medium-grain varieties. At the same time--because of the Italian production of short-grain rice--the area has a surplus of short-grain varieties.

U.S. Exports to the ECC

U.S. rice exports to the Common Market countries form a substantial part of U.S. commercial trade in rice. In addition, the European markets provide by far the major outlet for high quality U.S. rice.

U.S. rice exports have thus far been admitted fairly freely to the Community. In Belgium-Luxembourg and the Netherlands, imports of both brown and milled rice are free of duty. In West Germany, import duties are zero in the case of brown rice, and 15 percent ad valorem for milled rice. There are no import restrictions in these countries, and U.S. rice has been free to compete with rice from other world sources. Licensing restrictions are so severe in France and Italy that U.S. exports to these countries are rare.

EEC Consumption

The per capita consumption, though rising, is still materially below that of prewar. The free trade position of rice has contributed to the increase in consumption now going on, and has permitted the natural development of consumer preferences in use of rice. The rice marketing industry within these countries has an important stake in the existing import pattern as it now operates. This includes the highly developed rice industry in each of the four rice importing countries of the Common Market area, importing firms, packaging and processing firms, distributors and retailers.

The Proposed Common Agricultural Policy for Rice

Late in December 1963 the EEC Council approved the Commission proposal for a Common Agricultural Policy (CAP) on rice. The proposal is largely an adaptation of the CAP on grain--Regulation Number 19.

The only specific price that appeared in the proposal was $125 per metric ton which was designated as the minimum threshold

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price for short-grain brown rice in the four non-producing EEC countries.

The Council of Ministers, at their March 23-24 session, set the threshold price for short-grain brown rice at \$142 per metric ton, using the actual cost, insurance, and freight (c. i. f.) offers of California Pearl in North Sea ports for the period October 1963 through February 1965. The actual average c. i. f. price was \$132. 70 and to this they added \$2. 50 as a quality differential, plus an additional \$6. 80 per metric ton as called for in the basic regulation. This threshold price was to be used in determining the levy on imported rice into the non-producing countries beginning July 1, 1964. When adjusted c. i. f. price is determined by the Council, this will be subtracted from the \$142 to determine the levy. As an example, if the adjusted c. i. f. price, based on offers in the first week of July, was \$135. 00 per metric ton, then the levy would be \$7 per metric ton.

The threshold price for broken rice was established at \$96. 60 per metric ton using offers from Thailand.

At the same meeting, the Council set the upper limit of the target price at \$183. 20 and the lower limit at \$152. 90 per metric ton. These prices are to be used in the establishment of the threshold price in the two producing countries, Italy and France. In all probability, France will use the upper limit of \$183. 20 and Italy will use the lower limit of \$152. 90. Once these decisions have been arrived at. the threshold price for rice in these two countries will be determined in the same manner as they were determined for wheat; namely, subtract the marketing costs (transportation, handling, etc.) from port of entry to the deficit center for which the target target price is established and add a lump sum (which has not been determined as yet) plus or minus, as necessary, an adjustment for quality to determine the threshold price.

To date, this is as far as the Council has gone. They have been unable to agree on the quality differentials to be applied between short-grain and long-grain brown rice and the various varieties of milled rice. Because of this situation, there are rumors that the Council will delay the implementation of this regulation for 4 months to November 1, 1964. It is hoped that the Council will delay the implementation because it will permit U. S. and other third-country exporters more time in which to make their ideas and representations known.

Comments on the Proposed Common Agricultural Policy for Rice

During the transition period, the Regulation as adopted by the Council will not have too much effect on third-country imports. However, by 1970, when there will be one threshold price for all EEC countries, under the present scheme there could conceivably be a total exclusion of third-country rice because the threshold price will undoubtedly fall somewhere between the \$183. 20 upper limit and the \$152. 90 lower limit that are now proposed for Italy and France.

Another factor of great importance to the United States and third-countries is the differential between short-grain rice and long-grain rice. We are hopeful that the Council will use the same period--October 1963 through February 1964--in the establishment of these differentials because during this period the differential was \$12. 14 per metric ton. With a differential of less than \$15 per metric ton, the United States and other third countries would be able to maintain access for long-grain varieties.

In addition to the desirability of maintaining low differentials between short- and long-grain rice, United States has on several occasions pointed out the following to members of the EEC Commission who are working on the rice regulation:

(1) Only about one-tenth of the rice requirements of the four EEC non-rice producing countries are now provided by imports from Italy. France does not export rice to other EEC countries and actually imports rice from third country suppliers, including in 1962 and 1963 the United States.

(2) The rice-producing areas of the Community do not produce other than soft-cooking varieties of rice due to climatic and geographical factors.

(3) The Consumers of the EEC gradually have increased their preference for long-grain hard cooking types of rice. This trend has been going on for a long time and is expected to continue. At the present time, the long-grain hard cooking rice represents over half of the consumption requirements of Germany, and even a higher percentage in The Netherlands, Belgium, and Luxembourg.

(4) This dependence on outside imports cannot be offset by restricting imports through relatively high variable levies. Consumers of long-grain rice will, by and large, tend to consume the desired types of rice until prices are sufficiently high to act as a major deterrent. The demand for long-grain rice at such a point, unsatisfied by customary imports, will have a tendency to switch to other foods rather than to short-grain rice if consumers in the Community behave as they have in other areas of the world.

(5) That production is limited to one specific type of rice and that acceptance of this rice is very limited in the four non-rice producing countries have been ignored in the draft Regulations. The Community cannot become self-sufficient in rice by shifting its domestic consumption to the rice now produced in Italy and exported largely to other world destinations.

(6) Therefore, the result of a system of increasing the cost of rice imports from third countries is apt to be higher consumer prices within the EEC, lower consumption and about the same amount of surplus Italian rice that is now being subsidized to move into other world markets.

SOME EFFECTS OF ADVANCED TECHNOLOGY AND OF PRICES RECEIVED ON ADJUSTMENTS IN RESOURCE USE ON RICE FARMS

Troy Mullins [1/]

In recent years new cultural practices have given farmers higher per acre yields and have aided in holding per unit costs at reasonable levels, despite a continuing rise in costs of materials, equipment, and labor. Advanced technology, which farmers are expected to apply by 1975, likely will increase rice yields by about 38 percent compared with 1961 yields. Production costs will rise appreciably, but not as much as per acre yields. Hence, costs per unit of output likely will be some 10 percent less in 1975 than in 1961. If the price at which farmers sell rice can be maintained at the 1961 level, the per acre returns to farmers for use of their land and managerial services will be higher than in 1961.

Prices received are of interest to farmers, first because they play an important role in determination of incomes, and secondly because the relationship of prices received for the commodities adapted to his farm provides a guide for allocating the use of land and other production factors. Farmers usually consider the anitcipated market price at harvest-time for various commodities in making annual changes in the acreage of each crop which they commonly plant. In the Northeast Arkansas area, where cotton, soybeans, wheat, and other feed crops are grown on rice farms, an analysis of the influence of prices received on the most profitable combination of enterprises indicates that:

1. At 1963 prices, rice gives a substantially higher per acre returns than either cotton or soybeans;

2. With the price of cotton and soybeans at the 1963 level the price of rice could decline about 30 percent before it would be profitable for farmers to shift land from rice to cotton, and somewhat more than this before it would be profitable to substitute soybeans for rice;

3. Should the price of rice be stabilized at the 1963 level of $4. 90 per hundred pounds, the price of cotton would have to rise to 38. 0 cents per pound, and soybeans to $3. 70 per bushel before it would be profitable to reduce the rice acreage in favor of these crops.

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PANEL DISCUSSION ON EDUCATION AND EXTENSION

MODERNIZING RICE EXTENSION TECHNIQUES [1/]

Our panel hopes to tell you why and how we believe rice Extension methods need to be changed to better fit them to a rapidly changing situation on the rice farms and in the rice industry of the United States. We all agree we are in a dynamic technological, economic, and social period. Research findings are coming fast and they are needed at an increasing rate by agribusiness. Agriculture already has changed very markedly and will continue to advance even more rapidly. Dr. Troy Mullins of the University of Arkansas has just told us how he is using the computer in his rice crop management studies with farmers.

We recognize several factors are involved. The knowledge explosion of the 20th Century has triggered a chain reaction in all facets of the farm economy. How are the Land Grant Colleges and the U.S.D.A. going to adjust their old line organizations to fit this new pattern?

1/ Panel members included: Glen R. Harris, California rice grower, Director of Rice Growers Association of California, and member of U.S.D.A. Rice Research Advisory Committee; John Lindt, Jr., University of California, Rice Area Farm Advisor; W. A. Harvey, University of California, Extension Weed Control Specialist; D. S. Mikkelsen, University of California, Agronomy Department; Lewis C. Hill, Louisiana State University, Extension Rice Specialist; R. J. Miears, Texas A. & M. University, Extension Agronomist; and Milton D. Miller (Moderator), University of California, Assistant State Director of Agricultural Extension Service.

Question: Is there a real need to change our method of doing Extension work, particularly rice Extension work?

Harris: Yes! I am happy to report that in 1961 the California Agricultural Extension Service began moving toward cross-country-line or area crop specilization, with rice farmers as the "test plot." Three area rice specialists now work in a total of eight counties which produce 5/6 of the State's rice. The test has proven so highly successful the University of California now is rapidly expanding this method of doing Agricultural Extension work in the State. Up until this change I had felt that insofar as the rice industry was concerned there was urgent need for modernization in Extension methods. Some years ago I had noticed in connection with our own Rice Experiment Station and Extension activities that farmers were increasingly going directly to the Station for solution to their problems instead of attending Exetnsion meetings and demonstrations. Since the beginning of our rice industry about 50 years ago, California rice farmers have developed a good general knowledge of the crop. An Extension man who had responsibility for a dozen or more crops, and 4-H Club work as well, could not possibly keep astride of the detail of new technical knowledge. It was this detail we needed. It was time for the Extension man to become highly specialized if he was going to provide us with the answers we need. Our area Extension rice specialists have provided the answer to the question on how to do Agricultural Extension work in the last half of the 20th Century!

Harvey: I agree! From the standpoint of the state university specialist, it is a lot easier to work with a few area or county rice specialists than to work with innumerable farm advisors who spend only 15 percent or less of their time on rice and probably on 1 or 2 percent on weed control problems on rice. When our local Extension workers are thinking and concentrating on one or two crops, it is easier for us to help keep them on top technically.

Question: Shall we talk more about the advantages of specialization of Extension workers?

Harvey: As a county or area farm advisor specializes he becomes more competent to provide growers, through local experimentation or experience, with answers to problems which formerly could only be provided by researchers from the more distant state university or field station. This then frees the experiment station researchers to concentrate on basic research, which in turn helps to answer the more difficult problems now being encountered by the local specialist in the field and farmers.

Question: R. J. Miears, you are in a state which has an agriculture which in complexity approaches ours in California. Do you find in Texas there is a new group of people who, with considerable competence, are contacting farmers and giving the advice?

Miears: Yes! It is true that many very well qualified commercial company representatives are now advising farmers. Thus, we in Texas rice Extension are dealing with a somewhat different clientele than in the past. Whereas in the past the state specialist's function was almost exclusively to train local county agents (farm advisors), a part of our time is now spent helping to train these commercial workers and producers in subject matter. Rice producers are progressive and aggressive and are demanding much more technical information. They tend to want to go directly to the man doing the research work. For this reason we are encouraging our local workers to participate in field demonstrations and experimentation, particularly in cooperation with area field stations. This experience tends to better equip Extension workers as true specialists. Another step has been taken to better serve Texas rice producers. We are using an increasing number of area or multi-county specialists.

Question: What about the situation in Louisiana?

Hill: I don't think the situation in Louisiana is any different from that just described. We are changing to meet situations you have just heard discussed. What will be necessary to do in Texas or California may not be exactly the same as in Louisiana. We don't have the great distances to travel that you have. However, similarly we are moving into the field with area specialists. We have some at the present time but we probably will not progress in this direction as rapidly as you in California and Texas have. Then, too, we are approaching the problem from within the parishes rather than going across lines. Basically, however, we are seeing specialization. In parishes where several crops are grown one man may deal with rice and cotton, another with sweep potatoes, corn and soybeans, and another may handle livestock and pastures. Another program we have going is one whereby we are asking certain specialized agents to work with a number of farm people in looking at their total programs. We are going into farm level management problems with computer programming as the key tool. We have pilot farmers on this throughout the state. We are changing all along the line as necessary to get the job of Extension done better.

Question: John Lindt, as University of California Area Farm Advisor specializing in rice for over 2 years, what audience do you find you now serve?

Lindt: I think there are two distinct audiences. First, we are working with organized industry groups wuch as the people in agricultural chemicals, milling, drying, and storage. Secondly, we still have a big clientele of farmers with production problems. Incidentally, we continue to have good attendance at our rice grower field and indoor meetings. In our 1964 rice meetings in the Sacramento Valley the average attendance was about 100.

We need Extension people who have detailed technical knowledge, who at the same time have a broad perspective on the whole matter of maximum efficiency in all aspects of rice crop production. Some of the growers' problems are connected with correlating everything which is known about rice production. There have been comments about growers going direct to the experiment station. We in Extension are dependent on the men in research for basic information. If you encourage us to work and cooperate with you on the applied phases of your research, we will then be able to answer the farmers' questions and thus save you valuable time for more basic research. In California we have a fine group of commercial people who provide a lot of service type work to our growers. We are dependent on these people to conduct a good part of the educational program for us. That is why we in California Extension like to work with them so that they have the latest scoop when they do contact rice growers.

Question: (To Lindt) You don't look upon the commercial field representative as a competitor?

Lindt: No! Quite to the contrary, I see a real opportunity for more people to go into commercial agricultural advisory work. As we in Extension tend to specialize and become engaged, in part at least, in problems solving experimentation, they increasingly are going to become our colleagues rather than competitors in serving the technical needs of rice growers.

Question: You have heard John say area specialists should extend information and also be engaged in applied research. Now that our California rice Extension specialization program has been underway for 2 years, have you researchers found a slackening of requests from farmers for direct assistance?

Mikkelsen: Yes, there has been a marked tendency for the local rice production problems to be taken to rice area farm advisors who really know their business. It used to be that Bankers' short courses in agriculture would only be given by faculty and state level Extension specialists. Now that we have developed specialized county and area Extension people who have developed knowledge and confidence, these are being conducted

by them without state level help. Our job is to keep them armed with new, up-to-date information. By so doing, we have proven to farmers and the agribusinessmen that the local Extension man can be as expert, and perhaps more so because of his local experience, than anyone on crop production.

Question: If the local or area farm advisor will be working with fewer farmers and extending no small part of his information through commercial fieldmen and others, he should have more time available for other activities. How will this time be spent?

Mikkelsen: He can make excellent use of this time by teaming up with the researchers and state level Extension specialists in conducting needed local problem solving experimentation. Certainly the key to our success in American agriculture has been our intense research programs to solve applied problems. In the recent past we have used most of our available research information to increase yields and to produce quality products that are in consumer demand. Our accumulation of basic information largely now has been used. A real vacuum or lack of new findings is developing. Consequently, researchers are being asked to spend more time on fundamental research to help create new knowledge upon which the rice industry can advance. Therefore, we now must depend upon county or area specialist farm advisors to assist in carrying out more of the applied research program while we in the Experiment Stations concentrate on basic research. Last year the California Agricultural Extension Service conducted 5,889 field plots throughout the State. Our Extension Service is cooperating on an ever widening front in carrying on applied research programs. It is now the right arm of most California based research workers when it comes to applied field research.

Question: How is the pattern developing in Texas?

Miears: Until recently there has been a rather distinct separation of duties of the Experiment Station and Extension Service. Some Extension staff members now work part time with the Experiment Station. All in Extension now are encouraged to work very closely with other disciplines as well as with the Experiment Station staffs. There is a narrow line between good field demonstrations and good experimental field plots. We can take demonstrations and put in a few extra plots and make good, well designed experiments. We are doing this in many crops. Among others, we are doing it in rice, peanuts and sorghums, working closely with Experiment Station personnel.

Recent name changes reflect changes in direction and new approaches to the development and dissemination of agricultural information. Just this year the name of the Texas Rice and Pasture Experiment Station was changed to the Texas Rice-Pasture Research and Extension Center.

Question: The change underway is that Extension no longer is an informational center only, but increasingly moving into applied or problem solving research role?

Harvey: Yes, this is the way we see it. We in California Extension have been in field research for years. Without the Extension Service plots very few herbicides could be recommended today in this State. Very seldom does our research man do the field plots all by himself. The researcher helps design plots. They are now usually installed, conducted and sampled at the county level. Many times the research man has never seen the plots. He doesn't have to, because they are under the care of qualified colleagues. Our farm advisors have to be and are better trained today than ever before. They know how research is done. They know the chemistry of the chemicals we are using. They understand the importance of techniques to solve residue problems, etc. They now daily use most of the tools of the modern research scientist in their country-point problem solving activities.

Summary

Miller: Today there has been substantial agreement on the panel that great change is

underway in all fronts of the rice industry. This is concurrent and associated with the great knowledge explosion of the 20th Century which is vitally, hopefully favorably, affecting each and everyone of us, in and out of the rice industry. This change is proving a great challenge to research and Extension. In June 1964 we are starting the second 50 years of Extension. The challenges ahead to all people, including farmers, researchers, Extension specialists, area farm advisors, and all in the rice industry are going to be tremendous. We on this panel are confident that the next 50 years will bring beneficial changes. The question is, can we individually measure up to the opportunities these changes will bring? We know our time-proven, adaptable system of agricultural research and Extension will.

REGISTERED RICE VARIETIES

Rice Varieties that have been registered under cooperative agreement between Crops Research Division, ARS, USDA, and American Society of Agronomy - Crop Science Society through 1964.

Reg. No.	Variety	C. I. No.[1]	FAO G. S. No.[2]	Grain type	Year released	Station	Breeders producing	Description and data submitted by:
1	Arkrose	8310	207	Med.	1942	Ark.	Jones & Adair	T. H. Johnston
2	Bluebonnet	8322	222	Long	1944	Tex.	Beachell	H. M. Beachell
3	Bluebonnet 50	8990	1012	Long	1951	Tex.	Beachell	H. M. Beachell
4	Blue Rose	2128	217	Med.	1911	(La.)[3]	S. L. Wright[3]	N. E. Jodon
5	Caloro	1561-1	211	Short	1921	Calif.	Adams, Chambliss, & Jones	J. R. Thysell
6	Calrose	8988	1013	Med.	1948	Calif.	Jones & L. L. Davis	J. R. Thysell
7	Cent. Patna 231	8993	1014	Long	1951	Tex.	Beachell	H. M. Beachell
8	Colusa	1600	213	Short	1917	La.	Chambliss & Jenkins	J. R. Thysell
9	Fortuna	1344	220	Long	1918	La.	Chambliss & Jenkins	N. E. Jodon
10	Imp. Bluebonnet	8992	1016	Long	1951	Tex.	Beachell	H. M. Beachell
11	Lacrosse	8985	1017	Med.	1949	La.	Jodon	N. E. Jodon
12	Magnolia	8318	216	Med.	1945	La.	Jones & Jodon	N. E. Jodon
13	Nato	8998	1133	Med.	1956	La.	Jodon	N. E. Jodon
14	Rexoro	1779	214	Long	1928	La.	Chambliss & Jenkins	N. E. Jodon
15	Sunbonnet	8989	1019	Long	1953	La.	Jodon	N. E. Jodon
16	Texas Patna	8321	221	Long	1942	Tex.	Beachell	H. M. Beachell
17	TP 49	8991	1020	Long	1948	Tex.	Beachell	H. M. Beachell
18	Toro	9013	1134	Long	1955	La.	Jodon	N. E. Jodon
19	Zenith	7787	206	Med.	1936	Ark.	Adair	T. H. Johnston
20	Cody	8642	212	Short	1944	Mo.	Jones, Davis, & King	J. R. Thysell
21	Nira	2702	215	Long	1932	La.	Chambliss & Jenkins	N. E. Jodon
22	Mo. R-500	9155	1135	Med.	1956	Mo.	Adair, Poehlman, & Cavanah	J. M. Poehlman
23	Northrose	9407	1364	Med.	1962	Ark.	Adair & Johnston	T. H. Johnston & Seth E. Henry
24	Nova	9459	1365	Med.	1963	Ark.	Adair & Johnston	T. H. Johnston, G. E. Templeton, & J. G. Atkins
25	Vegold	9386	1366	Long	1963	Ark.	Adair & Johnston	T. H. Johnston & C. Roy Adair
26	Palmyra	9463	----	Med.	1963	Mo.	Jones & Poehlman	J. M. Poehlman
27	Belle Patna	9433	1334	Long	1961	Tex.	Beachell	C. N. Bollich, J. E. Scott, & H. M. Beachell
28	Gulfrose	9416	1339	Med.	1960	Tex.	Beachell & Atkins	C. N. Bollich, J. E. Scott, & H. M. Beachell
29	Saturn	9540	----	Med.	1964	La.	Jodon	N. E. Jodon

1 Cereal Investigation number--accession number of Cereal Crops Research Branch, Crops Research Division, ARS, USDA.
2 FAO Genetic Stock number--accession number of Food & Agriculture Organization of the United Nations--listed in World Catalogue of Genetic Stocks.
3 Private Breeder in Crowley, La.

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UNITED STATES DEPARTMENT OF AGRICULTURE
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